
**ADDIS ABABA UNIVERSITY,**

**SCOOL OF GRADUATE STUDIES**

**COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES**

# ASSESSMENT OF DOMESTIC SOLID WASTE COMPOSITION AND GENERATION RATE, IN SHAMBU TOWN, OROMIA, NORTHWEST ETHIOPIA

***A thesis submitted to the school of Graduate studies, Addis Ababa University, in partial fulfillment of the requirements for the Degree of Masters of Science (M.Sc.) in Biology*.**

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## Approval sheet

This is to certify that the Thesis presented by FILLE HULUKA entitled "Assessment of domestic solid waste composition and generation rate in Shambu town. Horo Guduru Wollega Zone ,Oromia Regional State ,West Ethiopia" and submitted in the partial fulfillment of degree of masters of science in Biology compiles with the regulation of the university and meets the accepted standards with respect to originality and quality.

Signed by examining committee

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# Acronyms

AAU- Addis Ababa University

AASBPDA- Addis Ababa Sanitation, Beatification and Park Development Agency

CL- Confidence Level

HHSW – House Hold Solid Waste

ISWM – Integrated Solid Waste Management

MSE-Micro and small enterprises

MSW – Municipal Solid Waste

NGOs- Non-Governmental Organizations

NHW – Non- hazardous Waste

PCPDSWGR – Per Capita per Day Solid Waste Generation Rate

PHPDSWGR-Per Household per Day Solid Waste Generation Rate

SES- Socio economic Status

SW – Solid Waste

UNEP- United Nation Environmental Program

## *Abstract*

*Improper household solid waste management has becoming a major environmental and public health problem in Shambu town as other towns of Ethiopia. The town has been experiencing very poor domestic solid waste management system, due to the absence of proper household solid waste collection and transfer services, absence of communal dumping containers and in-sufficient and inappropriate placement of landfill sites. Despite all the problems, there was no study conducted so far. This study is thus conducted to fill the existing gap. The study was conducted at Shambu town, Horo Guduru Wollega zone, Oromia Regional State, West Ethiopia, from March 10, 2018 to April 10, 2018. Systematic random sampling technique was used to select 80 households that are estimated to represent residents with different socio economic levels. This study was aimed to assess the quantity, composition and generation rate of domestic solid waste of the study area. The daily solid waste generated from those sampled households of the study site were collected and sorted in to its component. The weight of each component was recorded for seven consecutive days to determine the quantity, composition and generation rate of each household. Data analysis was made by using averages, percentages and ratios. Results of this study showed that on average a household generates 0.148Kg/cap/day. By taking the total population of the study area in to account, the annual household solid waste generation rate of the town was estimated to be 4296.05 tons. As field survey analysis illustrates; in this study area there is improper domestic solid waste management systems. The residents dispose domestic solid wastes along the road side, on open areas, near the residential sites, around burial sites, within plantation sites, etc… The Municipality office and authorities responsible for waste management of the town are very poorly equipped materially, financially and in terms of human resources to provide the expected services appropriately. This study recommends that the Municipality office and authorities responsible for waste management have to take considerable measures to alleviate the problem of waste management by allocating enough budget on the sanitation of the town, by giving regular campaign, education, and training programs at grass root level to create public awareness on waste management and by discussing with other levels of government and NGOs for sustainable improvement of waste management.*



***Key words- Shambu town, municipal solid waste, Waste composition, Generation rate, cross-sectional study***

# CHAPTER ONE

# 1. Introduction

## 1.1. Background of the study

From the days of primitive society, humans and animals have used the resources of the earth to support life and dispose of waste**s**. In the early time the disposal of wastes by human activities and other animals did not pose a significant problem because of small population size and large amount of land available for the assimilation of waste.

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 consequence of life (Techobanoglous *et al*.1993).

Waste is generated in any human settlement by day-to-day human activities which include: domestic, agricultural, commercial .institutional, construction and demolition and industrial activities. Population growth, socio-economic status, family size, varying consumption patterns, feeding practices of individuals, and families, seasons of the year, urbanization and industrialization are some factors that influence the generation rate of wastes (Salami, *et al*., 2011, Okeniyi and Anwan, 2012).

In every urban center huge quantities of wastes are generated by humans. The problems that related to wastes are intensified with gradual increase in waste generation and its poor management threatening public health and environmental pollution.

Waste management is one of the major environmental and health burdens around the world today and this is more pronounced in developing countries including Ethiopia. Mode of solid waste management differs for developed and developing countries, for urban and rural areas, and for residential, industrial and commercial places. In developing countries solid waste management is faced with challenges including low collection coverage and irregular collection services, insufficient refuse dumps as well as crude open dumpsites, burning without air and water pollution control, the breeding site of flies and vermin and the handling control of informal waste picking or scavenging activities. These challenges arise because of various factors which constrains the development of effective solid waste management system. Certain approach are

required to develop a working frame work for the management of solid waste, This covers solid waste minimization (social), waste recycling, (economic) and waste disposal (technical).

To achieve a sustainable solution to solid waste management information on its characteristics is necessary. However, the results of some studies on the characterization of solid wastes cannot be generalized towards different areas and seasons because of variants such as eating habits, consumption patterns, socio-economic status, family size and season of the year that can cause dramatic changes in composition and generation of wastes (Toboada- Ganzalez et al., 2010).Now a days the problems that are related to solid waste are intensified with gradual increase in waste generation and its poor management threatening public health and surrounding environment.

Inadequate solid waste management in the town has resulted in the accumulation of wastes on open lands, around the residential areas, and within the drains leading to environmental pollution (water and soil pollution) through leach ate from piles, air pollution due to burning without air pollution control, and clogging of drains all of which are threat to public health and to the surrounding environment. Thus, there is a need for improved waste management system of the study area.

## 1.2. Statement of the problem

Shambu is a capital of Horo Guduru Wollega Zone of Oromia Regional State which is situated at 315 kilometers to the Northwest of Addis Ababa. According to the current data from municipality office the total population of Shambu town is estimated to be 79,576, out of which 43,041 are males and 36,535 are females and the town has 11,174 households. This town is experiencing rapid urbanization, but is far from satisfying the infrastructure demands of its inhabitants. Its solid waste management is very poor. There are no officially designed solid waste collection and transfer services, no refuse dumping containers, insufficient and inadequate landfill sites and no effectively organized solid waste management systems. The inhabitants and organizations collect and dispose of the solid wastes where ever with no local management authority presently involved. Thorough observation of the study area showed that disposal of domestic solid wastes along the road side, on open spaces, in plantation sites, around the burial sites, around water banks and within drains (road canals) decreased the aesthetic values of those areas. Problems related with improper domestic solid waste management in the study area includes: problem to waste collecting workers( scavengers), site for breeding of disease causing micro-organisms and insect vectors which are threat for public health, pollute the nearby water bodies by flooding which results water borne diseases, reduce the beauty of the surrounding environment and so have negative impact on the attraction of investment and increased rate of climate change by uncontrolled burning and anaerobic decomposition of organic wastes which produces carbon dioxide and methane respectively. Despite all these problems; there were no significant study conducted so far. This study is thus conducted to fill the existing gap. The study was focused on determining the composition and quantity of domestic solid waste generated in the study area to provide valuable information to improve solid waste management strategies within the study town.

## 1.3. Objectives of the study

### 1.3.1 General Objective

- To determine the generation rate and composition of domestic solid wastes and come up with appropriate management strategies.

### 1.3.2 Specific Objectives

To identify the composition of household solid waste generated from the sampled households' of the study area

To determine household solid waste generation rate of sampled residents**.**

To compare and contrast the causes of variation in the generation rate of domestic solid wastes at different socio economic levels of the study site.

## 1.4. Research questions

### 1.4.1. General research question

What are the compositions and generation rate of domestic solid wastes produced from the residents of study site?

### 1.4.2. Specific research questions

What are the components of household solid wastes generated from the sampled inhabitants of the study area?

What are the causes of variations in the generation rate of solid wastes at different household levels?

How much solid wastes are generated per household per day and per capita per day from the sampled residents of the study area?

## 1.5. Significance of the study

It will be a base line to conduct further study on household solid waste.

It enables interested groups to identify the types and amounts of solid waste produced by human activities in this study area.

It will pave the way to properly manage household solid waste productions at different levels.

It gives some awareness for the residents about the impact of improper solid waste management on public health and on the surrounding environment.

Characterization of solid waste will pave the way for those interested groups to reprocess household solid wastes for different purposes..

It provides significant data for concerned authorities to design appropriate solid waste strategies.

## 1.6 Scope of the study

This study is aimed to carry out assessment on domestic solid waste composition and generation rate at Shambu town. It is also designed to recommend proper domestic solid waste management strategies depending on the composition results in the study area. It is expected that this study will have vital importance in providing significant data which is fundamental to design appropriate solid waste management strategies for concerned authorities or as step to conduct more study in the study area.

# CHAPTER TWO

# 2 Literature Review

## 2.1. General Condition of Waste

Different resources of the earth have been used by human beings and animals since the ancient time to support their life and dispose waste. In the early time the disposal of wastes by human activities and other animals did not pose a significant problem because of small population size and large amount of land available for the assimilation of waste. 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 consequence of life (Techobanoglous *et al*.1993). In every urban center huge quantities of wastes are generated by humans. The problems that related to wastes are intensified with gradual increase in waste generation and its poor management threatening public health and environmental pollution. So, these wastes are to be stored, collected, transported, processed and disposed of in an environment friendly manner, so as to keep the city neat and clean. Moreover, as the system handles huge quantities of solid waste, it is necessary to have detailed information on quantification and characterization of solid waste for proper handling of solid waste at different stages of the system. Presently, majority of Municipal Corporations/ Councils do not weigh their waste but the quantities are estimated on the basis of number of trips of trucks which carry the waste to disposal site. Moreover, the solid waste management system is not planned or executed rationally due to non-availability of authentic or relevant information on waste generation. As the solid waste quantities are increasing in all cities and towns due to urbanization and industrialization, these have raised concerns about the economic viability and environmental compatibility of the current waste management methodologies. The rapid urbanization that has been taking place during the 20th century virtually transformed the world into communities of cities and towns facing a big challenges on environmental issues in which most of them have to be addressed at international level (Smith, 2010). Among those environmental issues solid waste management is a critical one because as long as humans have been living in settled communities, solid waste generation has been unavoidable and critical issue both in developed and developing nations.

Waste is generated in any human settlement by day to day human activities. Population growth, socio-economic status, family size, varying consumption patterns, feeding practices of individuals and families, urbanization, and industrialization are factors that influence the generation rate of waste (salami et al. 2011, Okeniyi and Anwan 2012). In Ethiopia, alike other developing countries, the increase of solid waste generation is resulted from rapid urbanization and population booming. 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 (Dawit and Alebel, 2003). 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.

## 2.2. Waste Management

Waste management is carried out for monitoring of waste materials to reduce their effect on health, environment or aesthetic and to recover resources from it. Municipal agencies manage municipal solid waste from urban areas with the objectives of providing good sanitation facilities as also protecting public health and surrounding environment.

Mode of solid waste management differs for industrialized and developing countries, for urban and rural areas, for residential, commercial and industrial places. Improper waste management is one of the major environmental and public health burdens around the world today and this is more pronounced in developing countries. In developing countries solid waste management is faced with challenges including low collection coverage, irregular collection services, insufficient refuse dumping containers, crude open dumpsites and insufficient and inadequate landfills. Management for non-hazardous waste, residential, commercial and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while hazardous industrial waste is usually the responsibility of the generators.

## 2.3 Components of solid Waste Management

Solid waste management (SWM); is broadly refers to the material flow stream of waste from generation to ultimate disposal and comprises storage, collection, transfer, processing and disposal.

**Storage:** Waste size, type and generation rate of solid waste determines the type of storage to be used. Type and source of solid waste determines duration of solid waste storage at their source. Solid waste should be collected and disposed of from temporary storage site to final disposal site before breeding of various disease carrying vectors. Uncovered containers of waste are exposed to human and animal scavengers that litter waste around and create public health problem.

**Collection:** is the term that refers to the art of removing accumulated waste from generating source. The level of service for waste collection varies markedly in industrialized and developing countries. Industrialized countries services have expanded to the extent that over 90 percent of pollution has access to waste collection. In developing countries, up to 30-60% of the waste generated is not collected and less than 50 percent of the population is served (World Bank, 2006). Yet, it should be noted that municipal services in developing countries are handicapped by limited finances and an ever-increasing demand on urban services. The failure to provide adequate collection services poses serious threats to public health and surrounding environment.

Solid waste collection and transportation system in developed countries constituted about 70-80%. In USA, collection costs in 1986 were 10.4 billion dollars (Murray, 2007). Minimizing collection and transportation cost as well as maintaining adequate service provision is one component of an efficient solid waste management (Mir Anjum Altaf, 1996).

According to Addis Ababa sanitation, beautification and park development agency (AASBPDA, 2003), there are three made of collection systems. These are: Communal container collection-using lift and compacting trucks, institutional collection- using lift trucks and door-to-door collection-using compactor and side loader trucks.

**Transportation (/transfer)**: refers to transportation and haul of solid waste from a central point to distant final management facility (Gerald, 1997).

**Recycling:** is the diversion of material from solid waste discarded as useless and the use of materials for the same purpose as was originally designed for other use in its original form, or processing (treatment and reconstruction) of material to produce secondary raw material for other products (Gerald, 1997).

In industrialized countries recycling activities are widely practiced and are on the increase, primarily due to the political pressure of the high cost of waste disposal attributable to land shortage, increasing costs of sanitary landfills, the unwillingness of the public's part to have landfills located in their backyards, and stringent regulatory standards of waste disposal. In developing countries, on the other hand, which are still grappling with the basic tasks of collecting garbage, recycling of waste is carried out as a means of income generation.

**Composting:** is the biological decomposition and stabilization of organic waste. Composting can be beneficial when applied on land. Composting operations of solid waste include preparing refuse and degrading organic matter by aerobic condition of microorganisms.

**Thermal treatment (combustion /incineration):** is controlled burning of solid wastes implemented by local governments or private operators. It can be used to reduce the volume of the waste generated.

In addition to reducing volume, combustors, when properly equipped, can convert water in to steam to fuel heating systems or generate electricity. Incineration facilities can also remove materials for recycling. Burning waste at extremely high temperatures also destroys chemical compounds and disease causing microorganisms.

A variety of pollution control technologies significantly reduce the gases emitted in to the air including:

Scrubbers- devices that use a liquid spray to neutralize acid gases

Filters – remove tiny ash particles

Regular testing ensures that residual ash is non-hazardous before being landfilled (Chris Zurbrugg, 2003).

Confined and controlled burning, know as combustion, can not only decrease the volume of solid waste destined for landfills, but can also recover energy from the waste- burning process.

In many developing countries the domestic waste contains large amount of inert, such as, sand, ash, dust and stones and high moisture level because of the high usage of fresh fruit and vegetables. These factors make the waste unsuitable for incineration (Chris Zurbrugg, 2003).

**Solid waste disposal**: despite the effectiveness of source reduction, recycling, composting and combustion, there will always be waste that cannot be diverted from landfills. The safe and reliable long-term disposal of solid waste residue is an important component of integrated solid waste management (ISWM). Solid waste residues are waste components that are not recycled, that remain after processing at a material recovery facility, or that after the recovery of conversion products or energy (Techobanaglous et al., 1993).

In many developed countries, burial in controlled landfills continues to be the most prevalent means of disposing of solid waste including hazardous waste. On the other hand most of the municipal solid waste (MSW) in developing countries is dumped on land in a more or less uncontrolled manner. They make uncontrolled use of the available space, allow free access to waste pickers, animals and flies and often produce unpleasant and hazardous smoke from slow burning fries (Chris Zurbrugg, 2003). Anaerobic degradation of biodegradable organic wastes produce landfill gases in landfill sites. Landfill gases, with high content of methane (60%) are potentially explosive, and as such, needs to be controlled. In some means of controlling, the gas is not used, the gas can migrate off site, causing problem to the surrounding environment (Gerald, 1997).

A survey made on some randomly selected towns of Ethiopia shows that 86.6 percent used open dump to dispose waste while the rest used holes (Yami Birke, 1999). In Addis Ababa, more than 30 percent of the solid waste generated is dumped illegally to the environment (AASBPDA, 2004).

Table 2.1 Waste disposal methods

| **Method of disposal** | **Description** |
|---|---|
| Road side disposal | This is common in areas where there is no waste collection service. The municipal solid waste is usually disposed of by its generators anywhere along the public highway |
| Uncontrolled waste disposal in small local dumps | There is a primary collection service and incipient transport to a nearby site where waste are disposed of without any control |
| Uncontrolled municipal dumping | There is primary and secondary collection. MSW is transferred and disposed of without control in a site on outskirts of the city |
| Controlled landfills | There is primary and secondary collection. MSW is transferred and disposed of with moderate control in a disposal site designed for the purpose and located on the outskirts of the city. The waste is buried regularly. |
| Sanitary landfill | The sanitary landfill is designed, built, and run according to sanitary and environmental engineering criteria. The site meets legal requirements and applies an environmental monitoring program. Environmental impacts are minimal and the population is not against the project |

Source: "A frame work for the disposal of municipal solid waste in developing countries" by Andrew cotton, Mansoor Ali and Ken Westlake, loughborough: WEDC, 1998.

## 2.4. Source, Composition and Generation Rate of Solid Waste

Knowledge of solid waste types and their sources along with the data on its composition and rate of generation is basic to the design and operation of the functional elements associated with solid waste management (Tchobanaglous et al. 1993).

### 2.4.1. Source of Solid Waste Generation

Solid waste can be generated from different sources. This includes: residential, commercial, industrial, agricultural, construction and demolition, municipal services and treatment plant sites. Addis Ababa sanitation, beautification and park development agency (AASBPDA), 2004 stated that, the source of solid waste in Addis is estimated 76 percent from household, 18 percent from institution and 6 percent from street sweeping.

Municipal solid waste (MSW) is normally to include all community wastes with exception of industrial and agricultural wastes.

### 2.4.2. 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). Household solid waste composition can be categorized as biodegradable, disposable and recyclable. Current studies made on solid waste in different parts of Ethiopia, such as Addis Ababa sub- cities, Jimma town, Bahir Dar institute of Technology (BSIT), Hawassa University campuses, revealed that biodegradable solid wastes comprises more than 54 percent of the total composition of solid waste generated. Paper, cardboard and plastics are significant by mass in the composition of waste generated following organic wastes. Glasses and metals appear in negligible amount because they are not discarded for disposal but are sold to recyclable material buyers.

### 2.4.3 Generation Rate of Solid Waste

Solid waste generation: is the amount of waste released to waste stream by day-to-day human activities. Human beings can generate waste in their every day's activities. Socio economic strata, family size and technological advancements are some of the factors that affect the generation rate of household solid wastes.

**Socio economic status:** is an economic and sociological combined total measure of person's work experience and of an individual's or family's economic and social position in relation to

others based on income, education and occupation. Socio economic status (SES) is more commonly used to depict an economic difference in a society as a whole.

**Incom**e: refers to salaries, wages, profits, rents and any flow of earnings received

Socio economic strata**:** is one factor that affect generation rate of solid waste. Current studies made in some towns of Ethiopia revealed that solid waste generation rate depends on socio-economic levels of individuals or groups. As those study depicts, the daily per capita residual solid waste generation rate of individuals increase from low income groups to high income groups.

Family size: is also another factor which affects the amount of waste generated to the waste stream. In relation with individual income, as family size increase rate of waste generation also increase.

Technological advancement: also has influence on the amount of waste generated at the household level. As the living style of individuals change, the rate of waste generated per day also changes.

**Domestic Solid waste generated in some town of Ethiopia**.

| Study site | Per cap generation rate |
|---|---|
| -Jimma town (Dereje,2012) | 0.140 Kg/cap/day |
| -Lideta sub-city (Amsalu, 2017) | 0.229 Kg/cap/day |
| -Debre Berhan town (Asmamaw *et al*., 2017) | 0.253 Kg/cap/day |
| -Bahir Dar town (Kasahun, 2018) | 0.230 Kg/cap/day |

## 2.5 .Solid waste Characterization

Four methods of solid waste characterization were identified by Gerald (1997) for estimating the quantities and composition of waste. These are: direct sampling, material flow, surveying waste generators and literature source.

**Direct sampling**: can be used to estimate the composition of municipal waste streams. It involves collecting, sorting, and weighing materials from the waste stream of specific generator. This method uses to know the ways of obtaining representative samples and the amount of waste samples selected to achieve the desired level of accuracy in the result. There are two types of direct sampling. These are waste stream analysis and waste audit.

i) Waste stream analysis: is a method of collecting, sorting and measuring the amount and types of waste generated in the waste stream.

ii) Waste audit: involves a more detailed assessment of waste. Waste audit assesses both the waste (output) and its components (inputs) such as food products, packaging materials, office supplies, mail, or any process that results in materials that must be discarded.

**Material flow:** this method applies to the concept of conservation of mass to track quantities of materials as they move through defined system. It depends on the production weight data for materials and products. Data generation is important for making specific adjustments for imports exports and diversions to the production data by each material and product category. Material flow also considered the useful life of products. The problem with material flow method is that it is difficult to quantity food left in the container and detergent remaining in the package.

**Surveying waste generators** food processor industries can provide useful data in quantifying waste generation. More accurate data can be obtained if the wastes are measured at the disposal site.

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

# CHAPTER THREE

# 3. Materials and Methods

## 3.1. Description of the study Area

This study was conducted at Shambu town, Oromia Regional State, Northwest Ethiopia from March 10, 2018 to April 10, 2018. Shambu town is a capital of Horo Guduru Wollega Zone of Oromia Regional State, West Ethiopia which is situated at 315 kilometers to the Northwest of Addis Ababa. According to the data from municipality office, the current total population of the town is estimated to be 79,576 and the town has 11,174 households. The town was established in 1918 G.C. Geographically, the town is located between a longitude of $9^0$34'N and $37^0$06'E and at an elevation of 2,503 meters above sea level. The mean annual rainfall is 1,264mm HG. The mean temperature is $15.7^0$c (Shambu meteorological station, 2018). The town has two kebeles namely 01 and 02. The kebele which was considered for the study is Shambu 01 kebele .This kebele was selected because it is expected to generate much of domestic solid wastes due to the presence of institution such as hospital, teachers college, university, and site of commercial center. The total population of 01 kebele is 40,292 (male 21,749 and female 18,543).

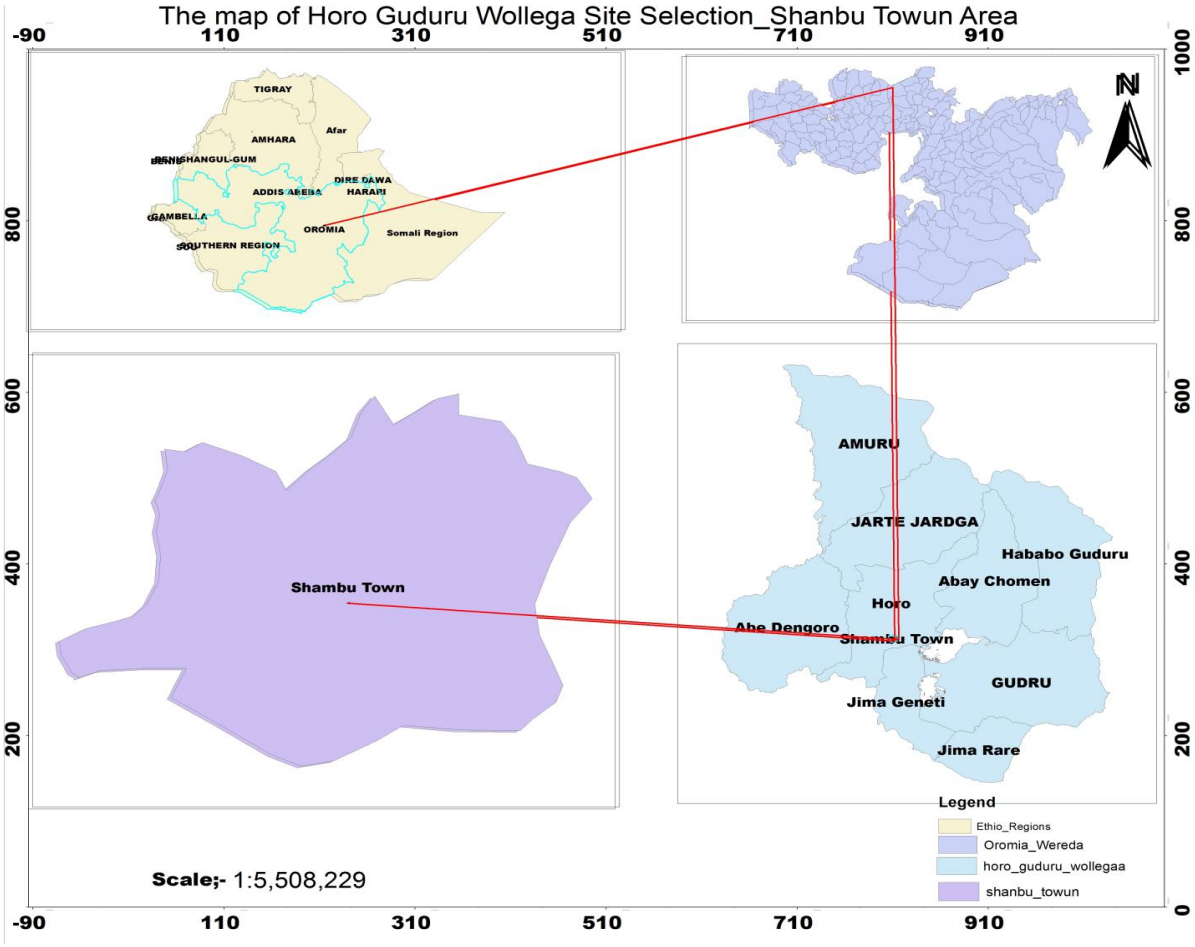


Figure 3.1-Map of  Shambu town(Map of  the study area )

## 3.2 Study design and sampling techniques

A community based cross-sectional study was conducted on 80 sampled households to assess the quantity, composition, and generation rate of household solid wastes produced by population of different socio-economic strata . Systematic and stratified random sampling techniques were used to select household samples from the targeted households, and to identify sampled residents with different socio economic strata. For higher statistical accuracy and confidence level(CL), the number of samples would be more .To calculate the number of samples of confidence level on solid waste data, the confidence level is usually set at 80% or 90%(UNEP, 2009).For determining the sample size of households a total of 410 targeted households were considered as a study site and the sample size of the households were determined by using sampling technique formula developed by Yemane(1973),with 90% confidence level and 10% margin error which helps to determine sample size with the degree of precision. The formula is as follows:

$$n = \frac{N}{1 + N(e)2} \qquad 3.1$$

Where n- sample size

N- Total numbers of households in the study site

e- Margin error

Therefore the sample size of households in the study site is:

$$n = \frac{410}{1 + 410(0.1)2}$$

n= 80(sample size of the households)

## 3.3. Data Collection Methods

Data regarding quantity, composition and generation rate of household solid wastes were collected from March 10, 2018 up to April 10, 2018 (in Spring season) by administering structured questionnaires to sampled house premises called sample points, by door-to-door waste collection from the sample point (source) and by field survey observation. Data on waste composition and generation were collected per day from each sampled household for seven consecutive days. Each sampled household was given plastic bags labeled with a corresponding house number to store the solid wastes generated per day. In the same way, other plastic bags with the label were given for each household for the next day collection and this process was continued until the last day of data collection for four weeks. Every morning the collected waste was brought to the selected working sites by trained waste sample collectors using hand push cart or horse cart. Finally the collected solid wastes were sorted out physically in to their categories, weighed and recorded.

## 3.4 Methods of Data Analysis

Data analysis of solid waste generation Per Household Per Day ( PHPDSWGR) and Per Capita Per Day Solid Waste Generation Rate (PCPDSWGR) of the sampled households were done by using Statistical Package for Social Studies (SPSS) version 20 Microsoft Excel 2007.

$$PHPDSWGR = \frac{Total\ solid\ waste\ generated\ in\ 7\ days}{7\ \text{days X Total number of sampled households}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3.2$$

$$\text{PCPDSWGR} = \frac{Total\ solid\ waste\ generated\ in\ 7\ days}{7\text{days x total family size of 80 sampled households.}} \quad \ldots\ldots\ldots\ldots \quad 3.3$$

### 3.5 Ethical Consideration

Official letter was written to Shambu municipality office, Shambu 01 kebele administrative and other concerned bodies to communicate about the research and for gathering required data.

## 3.6 Materials and Instruments

During the study time the following listed materials were used Audio and video cameras (for recording and capturing pictures of the working process), mouth and nose mask (to protect bad smell and inhalation of any fumes), hand protective plastic gloves (to protect hand from direct contact with dirt), plastic sheets (to ensure no loss of waste during sorting), plastic bags (to collect sold wastes from sampled households.), spring balance (for weight measurement of collected sample wastes) and trash bag (for handling materials needed to research work)

# CHAPTER FOUR

# 4. Results

## 4.1 Results from the survey

During the study period the sampled households were assessed for socio economic status, solid waste handling practices, domestic solid waste generation rate, option used to reduce generation rate of solid wastes and composition of household solid waste generated. Out of the 80 sampled household heads 81.25% of the respondents were males and the rest 18.75% were females. The average .family size of the sampled households was 4.5.

## 4.2 Socio economic status (SES) of sampled households

### 4.2.1 Economic status of head of sampled households

Individuals with different income levels participate in the society differently. Income is important to feed the family properly, for clothing and schooling, to be diagnosis when sick and for having access to credit. Figure 4.1 shows economic status of head of sampled households.

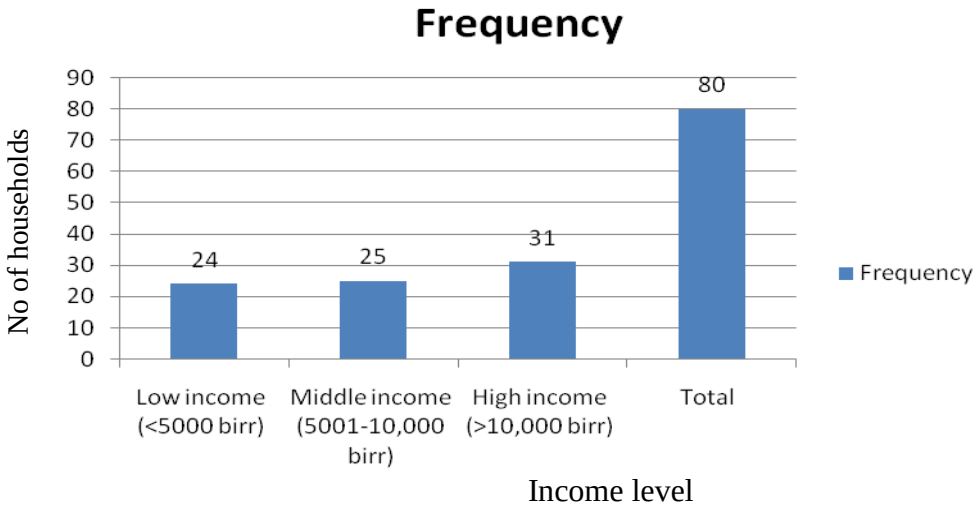


**Figure 4.1 Income levels of sampled family members per month**

The head of sampled households were assigned to different economic levels based on their monthly income they earn. According to the data on Figure 4.1, 31, 25, and 24 of head of the sampled households were assigned as high middle and low income level respectively. The study assigned income level of sampled individuals in to three as low income for those income is

below 5,000 birr, middle income for those income is from 5,001 to 10,000 and high income for those income is above 10,000 birr, per month.

### 4.2.2 Educational status of head of sampled households

Education plays a major role in skill sets for acquiring jobs. It is also one of the factors that stratify people with high socio economic status from low socio economic status. Table 4.1 shows the educational status of head of sampled households.

Table 4.1 Educational status of head of sampled households

| Educational levels | Frequency | Percentage |
|---|---|---|
| Adult education | 18 | 22.50 |
| 1 – 8 | 10 | 12.50 |
| 9 – 10 | 16 | 20.00 |
| Diploma | 13 | 16.25 |
| Degree | 14 | 17.50 |
| Masters | 9 | 11.25 |
| Total | 80 | 100.00 |

According to the data from table 4.1 educational status o f 55% of head of the sampled households range from adult education to tenth complete and the educational status of 45% of head of the sampled households range from diploma to masters level.

## 4.3 Energy availability of sampled households

The sampled residents in the study area use different materials as energy source for making and cooking food daily. Table 4.2 illustrates energy availability of sampled households.

Table 4.2 Energy availability of sampled households

| Item | Frequency | Percent |
|---|---|---|
| Firewood and eucalyptus leaves | 10 | 12.5 |
| Firewood, eucalyptus leaves and charcoal | 31 | 38.75 |
| Firewood, charcoal and kerosene | 24 | 30 |
| Firewood, charcoal, kerosene electricity | 15 | 18.75 |
| Total | 80 | 100.00 |

According to the data from Table 4.2, all of the sampled households use firewood as the main energy source for making and cooking food daily; and 51.25% households out of 80 sampled households use fire wood, eucalyptus leaves and charcoal (materials that produce ash) as the main energy source and 18.75% of the households uses electricity as additional energy source for making and cooking food.

## 4.4 Solid waste handling practices of sampled households

At the study area, solid waste handling practice at the household level was mainly the responsibility of the mothers and daughters when compared with other family members. Totally, there is no sorting of solid wastes in to their categories in the sampled community members. Table 4.3 shows the availability of temporary storage material at the household level.

Table 4.3 Availability of Temporary storage materials at household level

| **Availability of storage material** | **Frequency** | **Percent** |
|---|---|---|
| Available | 51 | 63.75 |
| Not available | 29 | 36.25 |
| Total | 80 | 100.00 |

According to the data from Table 4.3, out of the total 80 households; 63.75% of the sampled households have temporary storage materials which include: sacks, plastic bags, baskets and cartons. The rest 36.25% of the sampled households have no temporary storage materials at the household level and so they throw the domestic solid wastes on the street, on the nearby open spaces and within the drains (road canals).

### 4.4.1 Domestic solid waste disposal practices of the sampled inhabitants.

The survey analysis and visual observation of the study area shows that absence of accessibility of household solid waste collection and transfer services, absence of communal dumping containers and inappropriate and insufficient placement of landfills, discourage the inhabitants to dispose domestic solid wastes along the road side (Plate 8), in the plantation sites (Plate 7), on open spaces(Plate 5), near the residential sites (Plate 9), around burial area (Plate 6), and within the road canal which are a major threat for public health and the surrounding environment.

## 4.5 Generation rate of domestic solid waste in the study area

### 4.5.1 Total generation rate per day per household

Total generation rate per household per day is equal to total weight of sampled solid waste in seven days divided by the total sampled households conducted. As Table 4.4 illustrates, the mean household generation rate of one income group was different from the other groups.

The total domestic solid waste generation rate survey of household's of the study area is estimated depending on the data collected from the sampled households. Results of quantitative data obtained from sampled residential houses through direct measurement of domestic solid waste generated were analyzed using tables, averages, ratios and percentages as the major summarizing tools. The average household solid waste generated by the sampled households was calculated with respect to socio economic level and comparative analysis of average waste generation rate would be done. Table 4.4 shows waste generation per day per household and per day per capita of sampled households of the study area.

Table 4.4 Waste generation per day per household and per day per capita

| **Level** | **Low** | **Middle** | **High** | **Total average** |
|---|---|---|---|---|
| Total kg | 98.4 | 108.75 | 174.84 | 381.99 |
| No. of HH | 24 | 25 | 31 | 80 |
| Population | 109 | 108 | 146 | 363 |
| Kg \|HH\| day | 0.585714 | 0.621429 | 0..805714 | 0.670952 |
| Kg \|cap\| day | 0.128965 | 0.143849 | 0.171076 | 0.147963 |

As the data analysis on Table 4.4 indicates the total average domestic solid waste generation rate of sampled households of the study area is 0.67 kg/ |HH/| day and the total average daily per capita residual solid waste generation rate is 0.148 kg/cap/ day.Table4.4 also depicts that the daily per capita residual solid waste generation rate and per household per day increases from low income groups to high income groups. In general depending on the survey data analysis and Table 4.4 this study shows that much of the domestic solid wastes generated in the study area were from those who are in higher economic level and better life standards.

According to the data from municipality office, the current total population of Shambu town is estimated to be 79,576. Taking this figure into account, the daily, weekly, monthly and yearly domestic solid waste generation rate of this town is estimated to be 11.77, 82.42, 353.1, 4296.05 tons respectively.

## 4.6 Composition of household solid waste of the study area

In determining the composition of waste to be disposed of, representative waste samples were taken and sorted in to their categories as depicted in Table 4.5.

**Table 4 .5 Description of solid waste component categories**

| **Waste category** | **Description** |
|---|---|
| Organic | Food waste, food trimming and yard waste (leaves branches twigs grass pruning's and trimmings). |
| Plastics | Plastic bottles expanded polystyrene plastic bags and other plastic materials. |
| Paper | Office paper, computer paper, magazines, glossy paper, waxed paper, newsprint, cardboard and old or torn books. |
| Metals | Ferrous (iron, steel, tins, cans), aluminum, brass, copper, etc. |
| Glass | Bottles , drinking glass , jars , mirrors , louvers , auto window screens , etc. |
| Other miscellaneous wastes | Sand , dirt , ceramics , ash , fine particles , textiles , leather and other materials not included in the above components. |

Source: Survey waste. Info,online.

Household solid waste composition categories of the study area include: organic waste, plastics, paper, metals, glass and other miscellaneous wastes. In this vein, the percentage composition of sampled residential solid waste component generated from households with respect to stratified socio economic levels were determined. Figure 4.2 shows the process of sorting and weighing of waste fractions.

Figure 4.2 Sorting and weighing of waste components

Household solid waste categories, total weight and their percentage in the study area are indicated in Table 4.6.

Table 4.6 Components of domestic solid waste by percent

| Waste category | Total(Kg) | Percentage |
|---|---|---|
| Organic waste | 191 | 50 |
| Paper | 57.30 | 15 |
| Plastic | 45.85 | 12 |
| Metal | 11.46 | 3 |
| Glass | 7.65 | 2 |
| Other miscellaneous wastes | 68.74 | 18 |
| Total | 382 | s100 |

.

Figure 4.3 shows comparative composition of domestic solid waste components by percent of the study area.

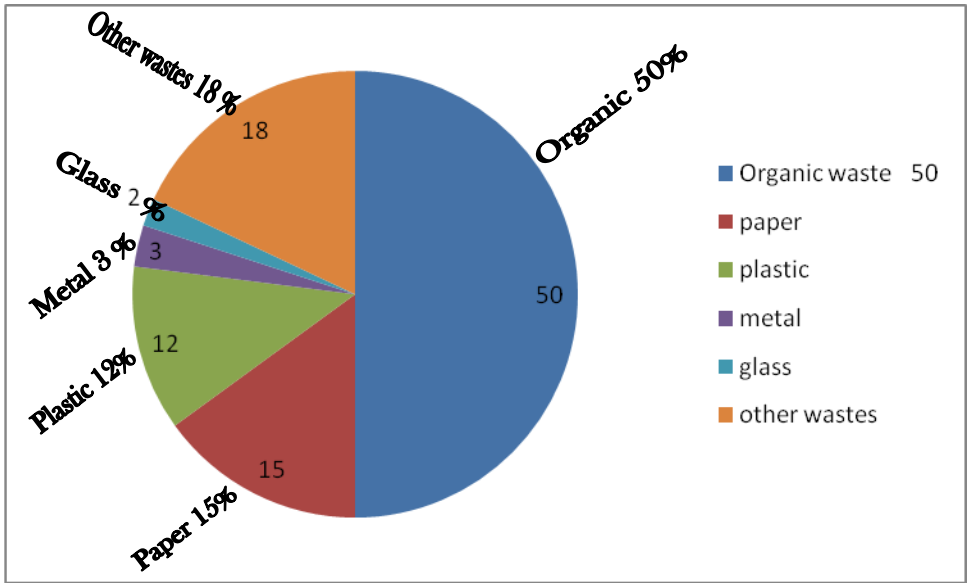


Figure 4.3 Overall physical compositions of household solid wastes.

. Data analysis from Figure 4, 3 depicts that organic wastes contributed the largest component (50 percent) of the total composition of solid waste generated. This is followed by miscellaneous

wastes which comprised of 18 percent of waste composition. The ash and dirt proportions in miscellaneous waste of the study area are high. This is because the sampled residents use fire wood, eucalyptus leaves and charcoal as the main energy sources for cooking and making food daily. Paper being comprises the third order that makes up 15 percent of the composition of the waste stream .Metals and glass appear in negligible amount because they are not discarded for disposal but are sold to recyclable material buyers.

From the survey data analysis and visual observation on the composition of solid waste generated at the house hold level of the study area, biodegradable waste comprises 50% of the total components of the waste, followed by disposable waste that comprises 43% of the total volume of the waste and the recyclable waste appear in negligible amount,7%.

## 4.7 Appropriate domestic solid waste management strategies

Appropriate solid waste management plays a vital role in keeping public health well and to keep surrounding environment safe. Proper solid waste management comprises storage, collection, transfer, processing and disposal. Thorough field survey of solid waste management of the study area depicts problem related with poor household solid waste management which include: low collection coverage by waste collector, absence of refuse dumping containers, insufficient and inappropriate site of landfills, and absence of appropriate awareness of the residents of the town on proper management of solid waste generated at different levels. So this study recommends that the municipality office of this town and other concerned authorities to allocate enough budgets, and plan on how micro and small enterprises and private sectors participate on proper solid waste management, build services such as refuse dumping containers and waste disposal landfills sites adequately at appropriate site, give appropriate awareness for the residents on the proper management of solid wastes generated at different levels.

## Discussion

In the study area, the head of sampled households were assigned in to three economic levels based on their monthly income they earn .According to the data on figure 4.1; 31, 25 and 24 of the head of sampled households were assigned as high, middle and low income levels respectively. As indicated in Figure 4.1; the monthly income level of 38.75% of the sampled residents is more than 10,000.This is due to the additional income they earn from different sources which include: presence of farm area from rural, having grinding mill, renting service classes, shopping during part time, and having more than two employed family members who have long service years.

The ranges of income levels in the study area are greatly varied from previous researches done on some towns of Ethiopia including Addis Ababa sub-cities (Amsalu, 2017), Jimma (Dereje, 2012). The causes of the differences within the ranges of income levels were estimated due to increment of living standard of individuals and increment of the value of dollar exchange.

Education plays a major role in skill sets for acquiring jobs. It is also one of the factors that stratify people with different socio economic levels. Higher levels of education are associated with better economic and psychological outcomes, i.e., more income, more control and greater social support and networking.

At the study area, solid waste handling practice at household level was mainly the responsibility of the mothers and daughters when compared with other family members. Totally, there is no sorting of household solid wastes in to their categories in the sampled community members of the study area .Most of the domestic solid wastes of the study area were not collected properly at household level. The sampled residents are facing problems of waste collection and transfer services before disposal.

According to the data from Table 4.3 out of the total 80 sampled households; 63.75% of the households have temporary storage materials which include: sacks, plastic bags, baskets and cartons. The rest 36.25% of the households have no temporary storage materials at household level and so throw domestic solid wastes on the street, on the nearby open spaces and within the drains (road canals).

Valuable waste materials such as plastic containers, scrapped metals and highland bottles are not discarded for disposal with other domestic solid wastes but are sold to recyclable material buyers. This helps to reduce the actual volume of waste disposed of at the household level.

The survey analysis and visual observation of the study area shows that the absence of accessibility of household solid waste collection and transfer services, absence of communal dumping containers and insufficient and inappropriate placement of landfill site, discourage the inhabitants to dispose of domestic solid wastes along the road side (Plate 8), in the plantation sites (Plate 7), on open spaces (5) around the residential sites (Plate 9), around burial area (Plate 6) and within the road canals which have a major threat for public health and the surrounding environment.

As data analysis from Table 4.4 indicates the total average domestic solid waste generation rate of sampled households of the study area is 0.67 kg/ |HH/| day and the total average daily per capita residual solid waste generation rate is 0.148 kg/cap/ day. As previous studies made in some towns of Ethiopia depicts, this study also shows that the daily per capita residual solid waste generation rate has direct correlation with income levels. The daily per capita residual solid waste generation rate increases from low income groups to high income groups. The total average domestic solid waste generated from the sampled households in the study area was 0.148 Kg/Cap/day. This figure has no significant variation when compared with similar study made in Jimma town .For example, the average daily per capita residual solid waste generation rate of Jimma town according to Dereje (2012) was 0.140 Kg/Cap/day .But there is significant variation in figure when this study is compared with studies made in Addis Ababa sub- cities, Debre Berhan and Bahir Dar towns. The average daily per capita residual solid waste generation rate of Addis Ababa city according to Amsalu (2017) was 0.229 Kg/Cap/day. The average daily per capita residual solid waste generation rate of Debre Berhan town according to Asmamaw, et.al.(2017) was 0.253 Kg/Cap/day and the average daily per capita residual solid waste generation rate of Bahir Dar town according to Kasahun (2018) was 0.230 Kg/Cap/day. Higher solid waste generation rate of these towns are attributable due to increased population sizes, high economic level and technological advancement of those residents when compared with the living standard of the residents of the study area.

The generation rate of domestic solid waste varies depending on socio economic strata, family size and technological advancement feeding habits of individuals consumption patterns of the families seasons of the year, etc According to the data analysis from Table 4.4 the daily per capita residual solid waste generation rate of sampled households increases from low income groups to high income groups ranging from 0.13 kg /cap/ day to 0.148 kg /cap/ day. This study also illustrates that in relation with individual income, as family size increases, rate of solid waste generated also increase .Technological advancement of individuals also has an influence on the amount and type of domestic solid waste generated. As the living style of individuals change, rate of waste generated also changes.

According to the data from municipality office, the current total population of the town is estimated to be 79,576. Taking this figure into account, the annual domestic solid waste generation rate of the study area is estimated to be 4296.05 tons.

The annual domestic solid waste generation rate of the study area has great variation in figure when compared with similar studies made in Jimma town. The annual solid waste generation rate of Jimma town according to Dereje (2012) was estimated to be 8,124.90 tons which is approximately twice that of domestic waste generated in this study area. This variation in figure is estimated due to the difference in the population size, economic variation and living standard of the residents of the two study areas,

Household solid waste composition categories of the study area includes: organic waste, plastics, paper, metals, glass and other miscellaneous wastes. In this vein, the percentage composition of sampled residential solid waste component generated from households with respect to stratified socio economic strata was determined.

As previous studies made in some towns of Ethiopia depicts; this study also illustrates that composition by mass of organic wastes coming from kitchens and gardens (yard wastes) primarily, comprises the largest amount of residual waste generated per household, followed by miscellaneous wastes. Paper and plastics also found in significant amount in the composition of household solid waste stream.

In this study area, the majority of the composition of solid waste is biodegradable waste which comprises 50% of the total composition of the waste, followed by disposable waste that comprises 43% of the total volume of the waste and the recyclable waste appear in negligible amount (7%).

From components of solid waste composition; biodegradable wastes comprise about 50% of the total percentage of domestic solid waste generated. So, the appropriate solid waste management strategy in the study area is composting which is not completely practiced.

Thorough observation of the study area showed that disposal of domestic solid wastes along the road side, on open spaces, in plantation sites, around the burial site, around water banks and within drains (road canals) decreased the aesthetic values of those areas and they are also threat for public health. Improper solid waste management in the study area has social, economic and environmental problems which include: problem to waste collectors (scavengers), site for breeding of disease causing micro-organisms and insect vectors, pollute the nearby water bodies by flooding, reduce the beauty of the surrounding environment, and increased rate of climate change by uncontrolled burning ($Co_2$) and anaerobic decomposition of organic wastes ($CH_4$). Appropriate solid waste management plays a vital role to keep public health and the surrounding environment safe. Proper solid waste management comprises storage, collection, transfer, processing and disposal.

In the study area the problem related with poor household solid waste management include: low collection coverage by waste collector, absence of refuse dump containers, insufficient and inappropriate site of landfills and absence of appropriate awareness of the residents of the town on proper management of waste generated at different levels.

# CHAPTER FIVE

# 5. Conclusion and recommendation

## 5.1 Conclusion

From the study conducted, Shambu town has been experienced poor domestic solid waste management system which includes: low collection coverage (8.33%), absence of refuse dumping containers, insufficient and inappropriate landfill sites. So, the residents throw solid wastes along the road side, in an open space near the residential sites, around the burial site, in a plantation sites, near water banks and within the drains which reduces the aesthetic values of those areas, and these wastes are threat for public health and the surrounding environment.

The total average domestic solid waste generation rate of sampled households of Shambu town per household per day is 0.67 kg/HH/ day and the total average daily per capita residual solid waste generation rate is 0.148 kg /cap/ day. For the total population of the study area, the daily, weekly monthly and yearly generation rate of domestic solid waste is estimated to be 11.94, 83.55, 358.09 and 4,356.79 tons respectively.

The study depicts that, socio economic strata, family size and technological advancement affect the quantities of solid waste generated. Previously on this study site; no researches have been done on the assessment of the composition and generation rate of domestic solid waste management. To have complete picture on the composition and generation rate of household solid waste, similar studies should have to be conducted to update and modify the data and information regarding domestic solid waste at the kebele and town level and planning proper solid waste management accordingly.

## 5.2 Recommendation

The study shows that although Shambu town has about 79,576 residents no considerable measure have been taken by municipality and other responsible authorities to alleviate the problems of solid waste disposal. The main issue that makes domestic solid waste management difficult in the study area are absence of collection services, no communal dumping containers and insufficient and inappropriate placement of landfill site. The following points are recommended for the improvement of the services and for the efficient solid waste management.

- The administrative and the municipality office should to plan and allocate enough budgets for Micro and Small enterprises and private sectors on the sanitation of the town.
- The municipality should think about the proper management option of the solid wastes.
- As was seen from the study area, there were no communal dumping containers and only one landfill site. For efficient collection and transfer of solid waste the availability of refuse dumping containers and adequate dumping landfill areas are crucial. So, this study recommends that the municipality and other responsible authorities have to plan and execute fund for refuse dumping containers and distribute them to appropriate site of the town and prepare adequate landfill sites for the final waste disposal.
- The municipality should encourage the community to participate on disposal fees which is payed for micro and small enterprises based on the volume of the refuse generated in each household. If so the amount of refuse generated will be reduced.
- Solid waste management requires a coordinated and collective effort. Regular campaign, education and training programs should have to be given at the grass root level to create public awareness.
- The municipality office and other authorities should have to discuss with other levels of government and NGOs for sustainable improvement in solid waste management.
- From the components of solid waste composition; organic waste comprises 50% of the total percentage of domestic solid waste generated. So, the appropriate household solid waste management in the study area is composting.

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# Annex 1: Survey questionnaires

## For assessing socio economic status, waste composition, solid waste disposal methods and sold waste management of sampled residents.

### 1. Demographic and socio economic status

Name of head of the household ----------

Sex---------- Age----------Occupation ----------

Educational status ----------Kebele ----------

House number ----------Number of family members ----------

Marital status----------

### 2. Composition and quantity of domestic solid waste

| Category | Round | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 4th | 5th | 6th | 7th | 8th | Remark |
| Food waste | | | | | | | | |
| Yard waste | | | | | | | | |
| Plastic | | | | | | | | |
| Paper | | | | | | | | |
| Metal | | | | | | | | |
| Others | | | | | | | | |
| Total | | | | | | | | |

### 3. Availability storage material at household level

(Available /Not available)

If your answer is available, what is temporary storage material used?----------

4. Methods used to collect and transport household solid waste to the disposal sites----------
---
5. Accessibility of solid waste collection ----------
6. Where do you dump household solid waste refuse?----------
7. Do you minimize the production of household solid waste before disposal?

Yes---------- No ----------

If your answer is yes, which method do you use to reduce the solid waste generated?----------
---

Is the existing waste management of the municipality satisfactory?

Yes----------No----------

How is the work of the existing municipality services on domestic solid waste management?-----
---
What measure should have to be taken to improve improper solid waste management?----------
---
---
---
---- ----------

What is your suggestion about the final disposal of household solid waste to be environmentally safe and acceptable?----------
---
---
---
---

## Annex 2: Plates indicating domestic waste samples, sorting, weighing and improper waste disposal at different sites.

**Plate 1: Collected waste before sorting**

**Plate 2: Measuring waste before sorting by using spring balance**

**Plate 3: Sorting of solid wastes**

**Plate 4: Measuring the sorted waste**

**Plate 5: Solid waste disposal on open space**

**Plate 6: Solid waste disposal around burial area**

**Plate 7: Solid waste disposal in plantation site**

**Plate 8: Solid waste disposal along the road side**

**Plate 9: Solid waste disposal near residential site**

## DECLARATION

I decline that this thesis entitled "Assessment of Domestic Solid Waste Composition and Generation Rate, in Shambu Town,Horo Guduru Wollega Zone, Oromia Regional State West Ethiopia", is my original work and all references used are acknowledged. It also has never been presented in any university for fulfillment of any degree program,

Name: _Fille Huluka Hofosha___

Signature_____Date_____

This work has been done under my supervision

Name: Habte Jebessa Debella

Signature:_____Date_____