
# JIMMA UNIVERSITY COLLEGE OF MEDICAL SCIENCES, DEPARTEMENT OF ENVIROMENTAL HEALTH SCIENCES AND TECHNOLOGY

# SOLID WASTE CHARCTERIZATION AND ITS MANAGEMENT SYSTEM IN DUKEM TOWN, EASTERN ETHIOPIA

A research thesis submitted to the school of graduate studies of Jimma University College of public health and medical sciences in partial fulfillment of the requirement for the degree of masters of Science in environmental science and technology

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BANTEAMELAK TEFERA

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Jimma, Ethiopia

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Declaration

I, the undersigned, declare that this research paper is my original work and has not been presented for a degree in any other university and that all sources of materials for the research paper have been correctly acknowledged.

Name:_____.
Signature:_____.

This research paper has been submitted for examination with my approval as an advisor:

_____(Alemayehu Haddis, Bsc, Msc, Ass Prof.)
_____(Seid Tiku, PhD)

## ABSTRACT

Solid waste, which is a result of day-to-day activity of human being and animal that are normally solid and discarded as useless or unwanted, needs to be handling carefully. Dukem town, like other towns, in the country challenged with poorly managed solid waste activities. The aims of this study deals with analysis of the existing municipal solid waste management system, characterizing the physical and chemical composition of commercial and residential solid wastes, determination of the generation rate and disposal facility and other possible alternatives of waste management methods.

The survey was conducted in Dukem town, Oromia region near Addis Ababa on randomly selected 111 sample households. A systematic random sampling was used to select the study subjects. The solid waste generation rate of the town in low families was 0.09 kg/cap/day whereas middle and high-income families generated 0.24 and 0.45 kg solid waste per capita per day respectively. The existing solid waste management experience in the town is investigated and it is found to be not environmentally friendly as the solid waste is disposed indiscriminately on open field and roadside. The major sanitation problems in Dukem town are basically related to the lack of proper collection and disposal system of solid wastes in the town. Family size, income and educational status were found to be strongly associated with solid waste generation at household level ($P<0.05$). The result of this study will provide the documentation of baseline data of the solid waste generation rate of the town, which is prerequisite for further design of proper solid waste disposal system



**Key words**: Solid waste, waste management system, waste reduction, recycling and recovery

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**LISTOF ACRONYMS**

| | |
|---|---|
| AACSBPDA | Addis Ababa City Sanitation, Beautification and Parks Development Agency |
| CBO | Community Based Organizations |
| CSA | Central Statistical Agency |
| DSWGR | Daily Solid Waste Generation Rate |
| EEPCO | Ethiopian electric power corporation |
| ISWM | Integrated Solid Waste Management |
| Masl | Meters above sea level |
| MSE | Micro and Small Enterprises |
| MSWM | Municipal Solid Waste Management |
| PCPDSWGR | Per capita per day solid waste generation rate |
| RSW | Residential Solid Waste |
| SWMS | Solid Waste Management Systems |
| USEPA | United States Environmental Protection Authority |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Back ground

From the days of primitive society, humans and animals have used the resources of the earth to support life and dispose of wastes. In early times, the disposal of human and other wastes did not pose a significant problem, because the population was small and the amount of land available for the assimilation of wastes was large (Joseph A. Salvato (1982).

Rapid population growth and expanding urbanization have caused a drastic increase of the municipal solid waste generation and the variety of the waste composition (Nguyen et al. 2011). Municipal solid waste (MSW) consists of all types solid waste generated by households and commercial establishments, and collected by local government bodies (Bhada-Tata and Hoornweg 2011). The majority of substances composting MSW in developing countries include paper, kitchen wastes, plastics, metals, textiles, rubber, and glass.

According to Divas & Carole (1993), most cities in Africa with fast expansion of urban areas are characterized by lack of resources, institutional organization, and the capacity to provide basic infrastructure, which in turn has caused increased problem concerning the management of waste. Moreover, the lack of proper land use planning has resulted in the creation of informal settlements, with narrow streets that make it difficult for collection trucks to reach many areas of the cities. This leaves a large proportion of the population in the cities without any access to solid waste service.

One of the most accurate approaches for characterizing waste composition consists of collecting wastes at its generation sources and directly sorting it out into types of materials (Brunner & Ernst 1986; Martin et al. 1995).

Modern human societies have a number of reasons for studying the process of solid waste (SW) generation .For example, for purposes of urban development planning, the amount and kind of SW that is produced and the behavior of solid waste generation must be known. A detailed characterization of solid waste is also necessary for integrated SW management strategies to be successful (Sakai et al. 1996).

## 1.2 Statement of the problem

In most cities and towns of developing world, inappropriate handling and disposal of municipal solid waste is the most visible cause of environmental degradation, i.e., air pollution, soil contamination, surface & ground water pollution, etc., resulted from improper disposal of municipal solid wastes (WHO, 1996).

Solid waste management (SWM) is one of the critical concerns facing the developing countries because of the social, economic, and environmental implications once not properly managed. Studies show that only 30-50% of the waste generated in developing countries collected and managed properly (Dawit and Alebel, 2003).

Urban waste management has been a challenge for municipalities and urban governments in the developing world, largely due to poor infrastructure, bureaucratic competence, and limited institutional capacity of the municipalities. Municipalities throughout Ethiopia are not free of these problems they are facing major challenges with solid waste collection and landfill management. For instance, Addis Ababa, as the largest city in the country, as well as other smaller cities has grappled with an increasingly growing urban waste management problem (EPA/World Bank, 2004).

Many cities in developing countries face series environmental degradation and health risks due to the weakly developed MSW management system (Nguyen et al. 2011). As one of the fast-growing cities in this part of the world, Dukem town, Ethiopia is also facing the same problem. Consequently, a considerable amount of waste ends up in open dumps without any sorting or treatment and is exposed to human and animal scavengers.

The base of successful planning for a municipal solid waste management system is reliable information about the generation rate and composition of waste generated. The generation and composition of waste determines the decisions for appropriate management system. It is thus a prerequisite for solid waste program managers to have detailed information about the composition and generation of solid waste to set appropriate management system or plan. Thus, this research was conducted to determine residential and commercial solid waste characterization in Dukem town.

## 1.3 Significance of the study

The result of this study is expected to provide the following advantages to the town administration.

- To adopt the best alternative residential and commercial solid waste management options that are sustainable and environmentally friendly.
- Alleviate health impacts associated with municipal solid waste management.
- Creates job opportunity for unemployed residents of Dukem town and the surrounding rural community as well.
- Serves as the basic source of information about the impacts and appropriate residential and commercial solid waste management techniques.
- Invites individuals, communities and researchers to develop awareness about the ever increasing problems associated with household solid waste.

## 1.4 Scope of the study

Solid waste management encompasses wastes from sources such as residential and commercial areas. It also comprises of all activities including waste generation rate and composition, identification, waste collection, storage, transfer, waste processing and transportation , i.e. residential and commercial. However, the scope of this study focuses on residential and commercial solid waste composition and generation rate in Dukem town.

# CHAPTER TWO
# LITRATURE REVIEW

## 2.1 Definition of solid waste

Solid wastes mean any garbage, refuse, sludge, and other discarded solid materials. Including industrial, commercial, and agricultural operations and community activities, but does not include solid or dissolved materials in domestic sewage or other significant pollutants in water resources, such as silt, dissolved or suspended solids in industrial waste water effluents, dissolved materials in irrigation return flows or other common water pollutants (U.S. CFR, 1995).

Modern human societies have a number of reasons for studying the process of solid waste generation. For example, for purposes of urban development planning, the amount and kind of solid waste that is produced and the behavior of solid waste generators must be known. A detailed characterization of solid waste is also necessary for integrated solid waste management. According to UNDP (2004), waste management is a Complex task which must go beyond purely technical consideration to environmental, political, institutional, social, financial, and economic aspects. In this respect, rapidly growing economic development, urbanization, and improving living standards in cities have led to an increase in the quantity and complexity of generated waste, representing a phenomenal challenge. In urban centers throughout African countries, less than half of the waste produced is collected, and 95% of that amount is either indiscriminately thrown away at various dumping sites on the periphery of urban centers, or at a number of so-called temporary sites, typically empty lots scattered throughout the city (Mohammed, 2003).
strategies to be successful (Sakaietal, 1996).

## 2.2. Composition of solid waste

### *2.2.1. Physical composition*

The composition of solid waste is the prime consideration before considering any process for its disposal or combustion or recycling. According to Hall *et al*., (1993), solid waste composition analysis is important because the nature of the waste influences the mode of collection and the lives of landfill sites that can be estimated.

Knowing the characteristics, the physical component of a community solid waste is important for the following purposes: for the selection and operation of equipment and facilities, to assess the possibility for resource of energy recovery and to design and analyze disposal facilities (Joseph A. Salvato (1982):). Different literatures reported that large portion of solid wastes of developing countries was food wastes Tchobanoglous et al, (1993).

### *2.2.2. Chemical Composition*

Information on the chemical composition of solid waste is important in evaluating alternative processing and recovery options. If solid wastes are to be used as fuel, the most important properties to be known are (1) Proximate analyses, which include moisture content (loss at $105^0$C for 1 hr), Volatile matter (additional loss in ignition at $950^0$C), ash-residue (residue after burning), and fixed carbon (reminder) (2) Ultimate analysis, which includes percent of Carbon, Hydrogen, Oxygen, Nitrogen and (3) Heating value (energy value. (Tchobanoglous et al.1977).

In general , data for developing countries reveals that organic (C,H.N) comprises about 40- 50 % , inorganic substances (P,K ) 20-30 %, Moisture about 30 -40 % by weight , with less than 1000 Kcal of heat value (Abera Kumie, 1997)

## 2. 3 Solid Waste Generation Rate

There are significant variations in composition and quantity of solid wastes generated in different localities depending on economic status, geographical characteristics of land, rainfall, climate, habits of people what they eat and drink, the package material they purchase, etc. Solid waste generation rate quantities should always be expressed in terms of weight not volume, since the latter Varies with compaction (Vesiline and Rimer, 1981). The reason for measuring solid waste generation rate is to obtain data to determine the total amount of wastes to be managed (Tchobanoglous et al., 1981).

According to Environmental Protection Authority and World Bank study conducted in 2004, per capita amount of waste generated in Ethiopia ranged from 0.17 to 0.48 kg/person/day for urban areas to about 0.11 to 0.35 kg/capita/ day for rural areas. (EPA/World Bank, 2004). Similar finding was seen in study conducted for solid waste generation rate of the low income courtiers which was found to be 0.1 - 0.5 kg/capita/day (Ulrich et al.2005).

## 2.4 Collection of Solid Waste

The term collection includes not only the gathering or picking up of solid wastes from the various sources, but also the hauling of these wastes to the location where the contents of the collection vehicles are emptied (Tchobanoglous, 1993). There are three basic types of collection equipments: Human powered, Animal powered, and Engine powered. (According to Nurconsult, 1982 and AAHB, 1997)

Getahun T.et el (2011) reported that only 25 % of the community uses municipal containers for disposal by municipal system which is similar to the study conducted in Nairobi. (ISWA 2002) According to some surveys estimation, a household should get a container within 200 meters of his vicinity (Yami, 1999), and one container provides services to a maximum of 2000 people.

### 2.5 Waste Disposal and alternative waste management options

Solid waste disposal (the disposal of solid or semi-solid materials) resulting from human and animal activities that are useless, unwanted, or hazardous. Most of the municipal solid waste (MSW) in developing countries is dumped on land in a more or less uncontrolled manner. These dumps make very uneconomical use of the available space, allow free access to waste pickers, animals and flies and often produce unpleasant and hazardous smoke from slow burning fires. The safe and reliable long-term disposal of solid waste residues is an important component of integrated waste management (Tchobanoglous *et al*., 1977).

#### 2.5.1 Source Reduction, Reuse and Recycle

Source Reduction means decreasing the amount or toxicity of the materials that we thrown away. Effective source reduction promotes the use of products that generate the smallest environmental impacts (USEPA, 1990).

#### 2.5.2 Composting

Composting has been defined (Haug, 1980) as the biological decomposition and stabilization of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat. Therefore, the final product is sufficiently stable for storage and application to land without adverse environmental effects.

#### 2.5.3 Incineration

Incineration (mass burning with a Temperature of 900-10000c) is the term used for the combustion of solid wastes. In properly designed and operated incinerator, there is a substantial

reduction in the volume of waste material. The residue (ash) is eventually disposed of by landfill or used for road construction in some countries. The process is extremely hygienic and many of the problems associated with landfill, such as windblown refuses, rodents and flies, are completely eliminated (Hall *et al*., 1993).

## 2. 6 Factors affecting solid waste generation Rate

According to Tadesse (2004) demographic dynamics, socio-economic changes and consumption patterns are the main factors that affect the municipal solid waste generation & composition, which in turn affects the waste management system. According to Getahun T.et el (2011) Family size was positively correlated with total waste generation rate per households. A similar finding was also seen in other study on the relationship between family size and house hold generation rate, Al-Momani (1994) and Sujauddin et al (2008). From study conducted by Jones et al, (2008), even though family size and household waste generation was correlated, the relationship between waste production and house hold size was not a linear relationship.

Educational status of households was negatively associated with total generation rate per households and with per capita generation. Getahun T.et el (2011) Sujauddin et al (2008) and Afon and Okewole (2007) also reported in their study conducted in Bangladesh and Nigeria respectively that house hold waste generation rate is inversely correlated with the educational level of the house hold head.

From the study conducted on municipal solid waste generation in Jimma Ethiopia, the income of the house hold head did not show statistical relationship with the rate of waste generation Getahun T.et el (2011). This finding was opposed in study conducted by Al-Momani (1994) that found a positive correlation between MSW generation and the income levels of people.

# CHAPTER THREE

# OBJECTIVES

## 3.1 General Objective

- Solid waste characterization and evaluation of its management system in Dukem town.

## 3.2 Specific Objectives

- Characterize the physical and chemical composition of residential and commercial solid waste
- Determine the generation rate and composition of residential and commercial solid waste
- Evaluate the current solid waste management system.
- Recommend possible alternatives of waste management system.

# CHAPTER-FOUR
# METHODS AND MATERIAL

## 4.1 Description of the Study Area.

The study was conducted in Dukemtown. Dukem is one of the towns of East Showa zone which is found between Gelan and Bishoftu towns .It is the town situated at 37 kms from Addis Abeba to east. The weather condition of the town is 'Weyna Dega" and the average temperature of the town vary between $12^0$C and $28^0$C. The town is divided in to four kebeles. According to the information from Dukem town municipality at the end of 2011 the total population of the town is 35,549 from which 48 % are females. There 64 restaurants, 30 butcher houses and 6500 residential houses in the town. There is only one disposal site known as Mendelo located 15 kms away from Dukem town, which is found near Akaki.

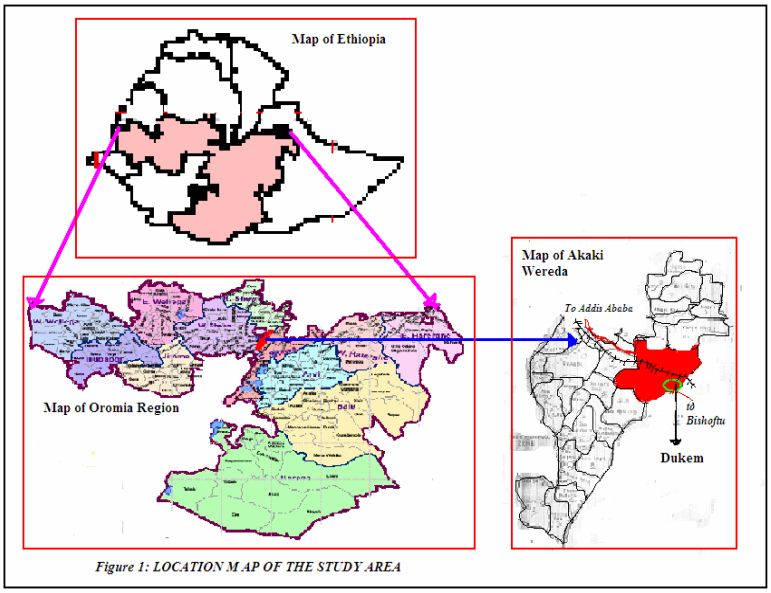


***Fig: 1 Map of the study area***

***Fig: 2 Solid Wastes from Abattoir Service in Dukem***

## 4.2 Study Population

For this study, the selected sampling method was stratified random sampling due to variability of the nature of the population under investigation. In this sampling method a heterogeneous unit, was divided into non-overlapping called strata. Each stratum was defined, so that internally it is relatively homogeneous (that is, the variability within each stratum was less than the variability observed over the entire population).

According to USEPA (2002), the strategy behind creating strata is to create homogeneous groups so that the variability is better controlled. Therefore, the groupings created in this planning stage should attempt to consolidate waste generators that are expected to have similar waste compositions.

The value of each stratum was determined based on proportional allocation. In proportional allocation, the sampling effort in each stratum is directly proportional to the size of the stratum. Then random sampling was conduct within each stratum. This information is summarized in (Table: 1). The study population is those number of units (samples) selected from the waste generators.

Table: 1 sample size of the respondents

| No | Name of Waste Generators | | Total Number in the town | Total number of the sample |
|---|---|---|---|---|
| **1** | Commercial | Abattoir | 1 | 1 |
| | | Restaurants and hotels | 64 | 3 |
| | | Boucher houses | 30 | 2 |
| | | Trade centers | 2 | 2 |
| | | Fuel station | 1 | 1 |
| | | Chat shops | 72 | 3 |
| **2** | Residential | Residential areas | 2060 | 99 |
| | Total | | 2230 | 111 |

**N.B:** The total number of sample population was 2230, where as the total number of the sample size was 111.

## 4.3 Study design and period

Cross- sectional study was applied and the study period was from March to May 2012.

## 4.4 Sample size determination

The adequate sample size of the population was obtained by the following formula. William, G. (1909). Cochran, sampling techniques.

$$n = \frac{n_0}{1 + n_0/N}$$ Where, $$n_0 = \frac{\sum_{h=1}^{7} N_h\, pq}{N\,(d\ /\ Z_{\alpha/2})^2}$$ if n/N<5%, n=no

Where $N_h$= sample size in the n waste generators

$n_o$= the initial sample size

n= the total sample size

N=Total waste generators

d= Margin of error =determined by investigator =10 %

$Z_{\alpha/2}$=1.96 at α=5% level of significance

P=proportion of success= assumed 0.5

q= 1-p=0.5

$$n_0 = \frac{\sum_{h=1}^{7} N_h \ 0.25}{2230\,(0.0026)}$$

$$= \frac{\sum N_h (0.25)}{5.0001}$$

$$= \frac{557.5}{5.0001}$$

$$\approx 111$$

$$n = \frac{111}{1 + \frac{111}{2230}} = 105.7$$

Since n/N=$105.7/2230$=0.0437 which is less than 5%

n=no so the sample size is 111

The proportional allocation is employed to select the sample from each waste generator by the following formula:

$n_h = n\ (N_h / N)$

### 4.5 Study variables

4.5.1 Dependent variable

Solid waste generation rate

4.5.2 Independent variables

Age

Sex

Family size

Income

Occupation

Educational status

### 4.6 Identification of residential and commercial centers for sampling.

To identify representative sampling centers for each group, random number was assigned and using simple random table randomization was done for each group separately and finally 12 selecting sampling unit commercial centers, and 99 selected sampling unit residential centers were identified.

After identifying the sampling unit, the responsible person was convinced about the study by explaining to them the benefit of the study. At the same time, questionnaires were also filled during field survey.

## 4 .7 Collection and sorting of commercial solid waste

Each participating commercial centre were provided with two or more plastic bags for their daily solid waste based on the amount of solid waste that they have been generating daily. This was to prevent both the overloading of bags and the hand ling of excess weight of materials. Waste was placed into clearly marked large plastic sacks to identify the bags as being from an individual property. This was also allowing the waste to be assigned to a particular business category for recording and interpreting data. Those plastic bags were collected and transported to the analysis site using a pushcart.

The sampling program was extended over eight successive days. A waste collected on the first day was discarded, as it has been seen the period they represent was doubtful. Wastes collected from the second to the eight days represent one week's solid waste production. The waste was collected each morning for sorting and weighting. The collected waste was first weighed to obtain the weight of waste for each commercial center. Weighing was carried out three times and an average value was taken. This procedure has been followed throughout the study period.

Waste was sorted into 14 containers by predetermined components of paper, plastic, glass, metal, food, textile, rubber, wood, yard, inorganic, electronic wastes, potentially hazardous waste, special waste. Periodically, during the analysis the 13 plastic containers were weighed and then emptied. The Plastic containers were weighed (three times as before) to record the amount of waste sorted in each predetermined categories. Finally, fourteen plastic containers were emptied into disposal facilities provided and these processes were continued until all waste analyzed.

## 4 .8 Collection and sorting of Residential solid waste

Each participating residential centre were provided with two or more plastic bags for their daily solid waste based on the amount of solid waste that they have been generating daily. This was to Prevent both the overloading of bags and the hand ling of excess weight of materials. Waste was placed into clearly marked large plastic sacks to identify the bags as being from an individual property. This was also allowing the waste to be assigned to a particular business category for

recording and interpreting data. Those plastic bags were collected and transported to the analysis site using a pushcart.

The sampling program was extended over eight successive days. A waste collected on the first day was discarded, as it has been seen the period they represent was doubtful. Wastes collected from the second to the eight days represent one week's solid waste production. The waste was collected each morning for sorting and weighting. The collected waste was first weighed to obtain the weight of waste for each commercial center. Weighing was carried out three times and an average value was taken. This procedure has been followed throughout the study period.

Waste was sorted into 13 containers by predetermined components of food waste, paper, cardboard, plastic, textiles, leather, yard waste, wood, glass, metals, ashes, special wastes, and hazardous wastes.

Periodically, during the analysis the 13 plastic containers were weighed and then emptied. The plastic containers were weighed (three times as before) to record the amount of waste sorted in each predetermined categories.

Finally, 13 plastic containers were emptied into disposal facilities provided and these processes were continued until all waste analyzed.

**Percentage composition and solid waste generation rate:** The percentage composition of each residential solid waste component generated from households was determined by dividing the total amount of a particular solid waste component type collected over a weak with the total amount of solid waste of all components within seven days and then multiplying it by 100. Similarly, the solid waste generation rate per capita per day (SWGRPCPD) was determined by dividing the total amount of solid waste generated from the sample households within seven days by the total number of persons over the sample residential houses then dividing the result by seven.

### 4.9. Proximate, ultimate and calorific value analysis

For Proximate, (Volatile matter content, free carbon remains, and Ash content after combustion), ultimate (C, H, N, S) and Calorific value analysis commercial solid waste samples were collected on 8/04/-8/5/2012. To select solid waste sample for proximate analysis, 12 commercial centers out of 170 commercial centers were used.

To get representative result in the analysis, the number of commercial centers in each category was made proportional to their proximate percentage in 4 sampled commercial centers. Then, 1

Kg food waste, 1 Kg paper, 0.8 Kg yard waste, and 0.8 Kg textile were collected. Then after the sample collection, it was taken immediately for analysis to Geological Survey of Ethiopia, Central Geological Laboratory-Hydrocarbon division.

Procedures used for analysis were summarized below. The laboratory sample consisted of four Sub-samples: putrescibles (food waste), Yard waste, papers (paper, cardboard) and textiles. The quantity of each fraction was 800 g to 1 Kg. For the temporary storage and transport of each sample to the laboratory, waterproof plastic bags were used. The time interval between collection and arrival at the laboratory was 3 hours. For the preparation of laboratory samples, necessary safety equipment like gloves was used. Size reduction of materials was achieved using knives and scissors. Volatile matter was determined after 6 minutes of ignition of wastes at 950 $^0$C and ash content was determined after burning of solid waste for 3 h at 750 $^0$ C. The calorific value of solid waste samples was determined by using a bomb calorimeter. Elemental or ultimate analysis was performed using a Vario El elemental analyzer.

### 4.10 Statistical Data analysis

The primary data obtained from sample commercial and residential centers through direct measurements (solid waste generation), questionnaires were presented using averages, ratios and percentages. Logistic regression with 95 % confident interval was used to see the association between dependent and independent variables.

### 4.11 Materials and Instruments

To carry out the analysis, a number of items of equipment like hand protective plastic gloves for handling, hand pushcart for transport of waste, scales capable of weighing up to 100kg, smaller range scales for detailed analysis, wood container for volume measurements, 10mm thick blue plastic sheets to cover the floor, plastic bags for collection and sorting of solid wastes, trash bag for collection of already processed wastes, video and digital cameras to record the research process and field observation were used.

### 4.12 Data quality assurance

In controlling data quality great care was taken starting from data collection up to handling the samples .Information collected through questionnaires was performed after the questionnaires are pretested and later the data collection was supervised by the researcher himself and the necessary checkups and data handling also owned by the researcher.

## 4.13 Ethical consideration

Research activities were commenced up on the approval by Jimma University ethical, research committee .The purpose of the study was clearly explained for the study participants, and to make sure them the study has no negative implication on their business. In every stage of the work the moral, cultural and other norms of the community else individuals had given due attention.

## 4.14 Dissemination of plan

Up on completion this study, a copy of the study will be given to Jimma university department of environmental health science and technology, Dukem town administrative office and other concerned bodies.

## 4.15 Limitation of the study

The major limitations that may affect the results of this study in some ways were waste generation rate and compositions depend on external factors, such as climate, seasons, and location so that the result may vary if repeated in different climate season and location. In addition the information collected on household waste generation rate may not reflect the actual amount they generate as some study participants may consider generating many waste may be not good.

# CHAPTER FIVE

# RESULTS

## 5.1 Socio-demographic and economic Characteristics

A total of 111 households were surveyed, of which 64 (57.56%) of the respondents were below 35 years whereas 47(42.42%) of them are above 35 year. Concerning educational status, 27 (24.4 %) of respondents had diploma and above education. On the other way, regarding monthly income of respondent's majority of them 95(85.6%) earns less than 400 birr per month.

**Table: 2** Socio-demographic and economic Characteristics of the respondents of Dukem town, 2012

| **Age in years** | Frequency | % |
|---|---|---|
| Less than 35 years | 64 | 57.56 |
| Greater than 35 years | 47 | 42.42 |
| **Educational status** | | |
| Primary | 15 | 13.5 |
| Secondary | 25 | 22.5 |
| Certificate | 17 | 15.3 |
| Diploma and above | 27 | 24.4 |
| Other | 27 | 24.4 |
| **Income** | | |
| Less than 400 birr | 95 | 85.6 |
| 400-900 birr | 10 | 9 |
| Greater than 900 birr | 6 | 5.4 |

## 5.2 Household solid waste generation rate

The solid waste generation rate of the town in low families was 0.09 kg/cap/day whereas middle and high-income persons was 0.24 and 0.45 kg/cap/day, respectively.

**Table: 3 Solid waste generation rate of Dukem town**

| Description | Low income | Middle Income | High income |
|---|---|---|---|
| Monthly income (per capita) | <400 Birr | 401-900 Birr | >900 Birr |
| Number of households | 95 | 10 | 6 |
| Average family size | 4.32 | 3.1 | 2.9 |
| kg/cap/day | 0.09 | 0.24 | 0.45 |

## 5.3 Factors affecting solid waste management at house hold level

Table -4 shows the result of the logistic regression on the strength of association between waste generation rate and socio demographic factors. Family size, income and educational status were found to be strongly associated with solid waste generation at house hold level .Those households with family size of greater than ten were found to generate three times more waste when compared with households with family size of one to five .Similarly family income greater than 1000 Ethiopian Birr per month is found to be significant predicator of house hold waste generation rate .For instance households with monthly income of greater than 1000 birr generate more waste when compared with those who earn less than 500 birr per month . Additionally educational status of the studied households showed positive relationship with the waste generation rate of the house holds. For example .Those respondents with educational status of diploma and above have more waste generated when compared to that primary education.

Table -4 Associations between waste generation and socio demographic characteristics, Dukem town. 2012

| Variables | | Solid waste generation rate | | COR(CI) | AOR(CI) |
|---|---|---|---|---|---|
| | | <0.5 kg/day | >0.5kg/ day | | |
| | | N (%) | N (%) | | |
| Family size | 1-5 | 33(39.2) | 12(14.2) | | |
| | 6-10 | 24(28.5) | 6 (7.1) | 2.879***(1.629- 5.087) | 0.385* (0.180-0821) |
| | >10 | 7(8.3) | 2(2.3) | 3.000***(1.693-5.314) | 0.101***(0.039-0.261) |
| Family income | Less than 500 | 31(37) | 24(27) | | |
| | 501-1000 | 9(11) | 10(13) | 0.587 (0.338-1.020) | 0.70*(0.007-0.714) |
| | Greater than 1000 | 4(5) | 6(7.0) | 0.497*(0.277-0.890) | 1.106(0.347-3.523) |
| Educational status | primary | 12(14) | 10(12) | | |
| | secondary | 10(12) | 13(15) | 0.748 (0.496-1.129) | 0.361**(0.193-0.674) |
| | certificate | 11(13) | 9(11) | 0.995 (0.597-1.657) | 0.688(0.305-1.551) |
| | Diploma and above | 5(6) | 14(17) | 25.050***(10.655-58.595) | 1.939(0.635-5.916) |

## 5.4 Domestic Solid Waste Composition

The major compositions of domestic solid wastes from the studied households, food wastes constitute 30.2 % by weight whereas metals constitute 0.4 % of the total household wastes by weight (Table -5). On the other hand, ash accounts for 23.3% by weight in the town. Metals, rubber and leather, wood, glass and ceramics were the least contributor of household's solid waste, which accounted for 0.4%, 0.4%, 0.5%, and 0.7% respectively. However, leaves and grass wastes were the largest contributor that accounted for 18.2% by weight.

**Table: 5 Domestic Solid Waste Composition by percentage of Dukem town, 2012**

| No. | Component | Weight in kg | Volume in $m^3$ | % by wt. | %by Vol. |
|---|---|---|---|---|---|
| 1 | Ash and fine sands | 30.1 | 43.5 | 23.3 | 13.5 |
| 2 | Dust | 20.2 | 40.3 | 17.2 | 12.3 |
| 3 | Food Waste | 41.3 | 120.11 | 30.2 | 32.6 |
| 4 | Glass and ceramics | 0.44 | 1.63 | 0.7 | 0.3 |
| 5 | Leaves and Grasses | 28.2 | 42.3 | 18.2 | 13.6 |
| 6 | Metals | 0.45 | 0.44 | 0.4 | 0.4 |
| 7 | Paper | 2.77 | 28.11 | 2.5 | 7.1 |
| 8 | Plastics | 4.22 | 32.1 | 2.1 | 11.6 |
| 9 | Rubber and leather | 0.66 | 4.55 | 0.4 | 1.6 |
| 10 | Textile | 2.13 | 11.2 | 1.7 | 2.7 |
| 11 | Wood | 0.60 | 2.77 | 0.5 | 0.5 |
| 12 | Others | 7.2 | 23.33 | 2.8 | 4.4 |
| | Total | 150.55 | 355.85 | 100.0 | 100.0 |

## 5.5 Household income and family size

As shown in table 8, the majority of the study subjects (85%) were low income family.

**Table: 6 Average family size of each income level of Dukem town, 2012**

| Status of households | Low Income<400 Birr | Middle Income401-900 Birr | High Income>900 Birr |
|---|---|---|---|
| Households | 95(85.5%) | 10(9.1%) | 6(5.4%) |
| Average Family Size | 4.32 | 3.1 | 2.9 |

## 5.6 Energy Sources

Regarding sources of energy, 62 households (55.8%) use Charcoal, wood, dung, paper and kerosene in addition to electricity for their source of energy. Only 27.9% have used electricity, kerosene, and charcoal.

**Table: 7 Sources of energy in Dukem town**

| Sources | House hold | % |
|---|---|---|
| Electricity, kerosene, charcoal | 31 | 27.9 |
| Electricity, charcoal, wood, paper, cow dung | 62 | 55.8 |
| Wood, dung, yard trimmings | 18 | 16.2 |
| Total | 111 | 100 |

### 5.7 Solid Waste collection and Disposal practices

Regarding solid waste collection, households have two options. The first option is that households themselves take their solid wastes and drop it into a container nearest to their home. The second option is having contract agreement with micro and small enterprise associations (pre-collectors) to take their wastes to the container. These options are mostly available at the centers and main roads; the peripheries dispose their wastes at ditches, river banks and open spaces.

Most households prefer the first option. This is because it has no collection cost or less cost that most households especially low income families prefer. Few of the low income, most of middle and high income households prefer to use the second option (per-collectors), and this accounted for only 33 (23.9%).

Very recently micro and small scale entrepreneurs started to engage themselves in solid waste management especially on pre-collection. Currently there are two groups of mainly young people including students in door-to-door collection of solid waste and transporting it to the communal collection containers.

#### 5.7.1 Road access to containers

Due to fast growth in economic activities and constructions, Dukem town is developing better main roads. But inner roads are not yet completed. Recent construction activities of all type

roads are not enough to all Kebeles to have access to main roads and other services. From table 8, 65 % households (58.6%) have access to communal solid waste containers. While 46 Households (41.4%) indicated that they do not have access to nearby container.

Table 8 Accessibility of road to Containers

| Accessible | No. of times | Frequency |
|---|---|---|
| Yes | 65 | 58.6 |
| No | 46 | 41.4 |
| Total | 111 | 100 |

**5.7.2 Distance to containers**

Regarding distances, most of the households are far away from the containers (Table 9). Only 12 Households (10.8%) are within the radius of 100 meters, 16 (14.4%) are found in between 101-200 meters, 18 (16.2%) are found between 201-500 meters. The rest 55 (49.6%) of the households have to move more than 500 meters to reach the container. Even there are families, 10(9 %), who do not know where the container is cited.

**Table9. Distances of containers from households**

| Distance | No. of times | Percent |
|---|---|---|
| 20-50 m | - | - |
| 51-100 m | 12 | 10.8 |
| 101-200 m | 16 | 14.4 |
| 201-500 m | 18 | 16.2 |
| >500 m | 55 | 49.6 |
| Do not know | 10 | 9 |
| Total | 111 | 100 |

Fig 3 Solid waste containers in Dukem town

### 5.7.3 On site solid waste handling

Most households 45 (40.5 %) use trash bag (festal) for their temporary waste storages, whereas 36 (32.4%) uses plastic bags. The rest households 19 (17.1%) use other materials such as baskets, metal buckets, and plastic containers.

## 5.8 Reused wastes

From table 10 below , 16 (14.4%) households compost wastes for soil enrichment for their gardens, cans and bottles are being reused by 51(45.9%) households and 31(27.9%) households reuse paper, wood, plastic and yard trimmings as fuel.

**Table: 10 Types of wastes reused in the town**

| Wastes | No. of times | % |
|---|---|---|
| Food wastes (home compost) | 16 | 14.4% |
| Paper, wood, plastics (for fuel) | 31 | 27.9 |
| Cans and bottles (Reused) | 51 | 45.9 |
| Not responded | 13 | 11.7 |
| Total | 111 | 100.0 |

## 5.9 Exchanged or sold solid wastes

According to exchanged or sold wastes in the town, most of the households 48(43.2%) household changed their worn out cloth, 21(18.9%) household wastes for plastic and other utensils to "Lewach" or sold their wastes to "Koralew". Besides, 25 (22.5%) households change or sell their worn out shoes.

**Table: 11 Exchanged or sold wastes in Dukem Town**

| Waste items | No. of times | % |
|---|---|---|
| Cloths | 48 | 43.2 |
| Shoes | 25 | 22.5 |
| Plastic and glass bottles | 21 | 18.9 |
| Not responded | 17 | 15.3 |
| Total | 111 | 100 |

## 5.10 Solid waste mass burning (Combustion)

As shown in the following table-12, 46(41.45%) households burn part or all of their combustible wastes on open air and 65 (58.55%) households never combust any of their wastes at all.

**Table 12: Solid waste mass burning conditions of households**

| Waste burning on open air | |
|---|---|
| Yes | No |
| 46(41.45%) | 65(58.55%) |

## 5.11 Composition of commercial solid waste

The percentage composition of commercial solid waste categories or fractions by volume showed that , food waste takes the largest proportion of commercial solid waste and followed by yard, paper, and plastic, and metals consecutively. Figuratively, food waste has 58.8 % of the total waste generated in commercial sectors and paper contributes about 10.0 %, yard is about 9.1 % by volume and plastic is 7.2 %, metals 5.4 % and the rest as a whole contributes 17.6 % for the total commercial solid waste generated in Dukem town by volume.

**Table: 13 Composition of commercial solid waste fractions by volume of Dukem town, 2012**

| No | Solid waste components | Weight in Kg | Volume in liter | % by weight | %By volume |
|---|---|---|---|---|---|
| 1 | Food waste | 76.2 | 86.56 | 61.6 | 48 |
| 2 | Paper | 9.76 | 18.94 | 7.9 | 10.5 |
| 3 | Yard | 8.24 | 17.24 | 6.7 | 9.6 |
| 4 | Plastic | 6.34 | 13.55 | 5.12 | 7.5 |
| 5 | Metal | 6.14 | 10.28 | 4.96 | 5.7 |
| 6 | Glass | 4.65 | 6.56 | 3.8 | 3.7 |
| 7 | Potentially hazardous waste | 2.68 | 5.28 | 2.2 | 2.9 |
| 8 | Inorganic | 2.36 | 5.14 | 2.0 | 2.9 |
| 9 | Textile | 1.94 | 4.38 | 1.6 | 2.4 |
| 10 | Wood | 1.68 | 3.94 | 1.4 | 2.2 |
| 11 | Special waste | 1.42 | 3.26 | 1.2 | 1.8 |
| 12 | Electronics | 1.25 | 2.74 | 1.0 | 1.5 |
| 13 | Rubber | 1.13 | 1.83 | 0.9 | 1.0 |
| | Total | 123.79 | 179.7 | 100.0 | 100.0 |

## 5.12 Chemical compositions

As shown in table 17, all waste categories had a volatile matter of greater than 63%.

**Table 14: Chemical composition of commercial solid waste generated from Dukem town**

| Components | Volatile matter (%) | Fixed carbon (%) | Ash (%) | Cal. Val (cal/gm) | N (%) | C (%) | H(%) | S(%) | C:N ratio |
|---|---|---|---|---|---|---|---|---|---|
| Food waste | 74.59 | 13.90 | 2.39 | 4638 | 1.57 | 40.79 | 7.07 | 0.29 | 25.98 |
| yard waste | 63.585 | 15.43 | 10.25 | 4016 | 1.61 | 36.74 | 5.69 | 0.27 | 22.82 |
| Textile | 72.63 | 6.93 | 15.54 | 3289 | 0.27 | 41.19 | 6.15 | 0.30 | 152.56 |
| Paper and cardboard | 71.48 | 8.405 | 14.865 | 4950 | 0.20 | 32.72 | 4.91 | 0.12 | 163.60 |

# Chapter six

# Discussions

## 6.1 Determination of Daily, Monthly and Yearly SW Generation Rate

The population of Dukem town in 2012 was 35,549. Taking this figure into account, the daily, monthly and yearly solid waste generation rate of Dukem town was 5, 152 and 1,830 tons respectively. The per capita generation rate of Dukem town found to be 0.143 kg/cap/day. 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 was 11,897 tones. Which is actually done in all waste streams and the population size was high, that is why the result became higher. Regarding solid waste generation rate, according to Gordon's estimations referred to in a report documented by AACSBPDA in 2003, the solid waste generation rate in Addis Ababa was estimated 0.15-0.252kg/cap/day (Bjerkli, 2005), this interval doesn't include the estimated solid waste generation rate of Dukem town (0.143) indicating there was some variations.

Households are categorized into three groups depending on their monthly per capita income of their family members. Per capita income level and solid waste generation rates have direct relationship (Wells, 1996). From the result in table 6, solid waste generation rate of Dukem town was higher in wealthy families. Similar trends were observed in Jimma town (Melaku, 2008).

## 6.2 Factors affecting solid waste generation rate

In this study, the result of the logistic regression on the strength of association between waste generation rate and socio demographic factors has shown significant association. Family size was positively associated with respondent 's waste generation rate and this finding is similar to the findings from study conducted on many regions of the world including Ethiopia (Getahun T.et el (2011), Al-Momani (1994) and Sujauddin et al (2008). Positive association was seen between income of the households and their waste generation rate. This was opposed by study conducted on municipal solid waste generation in Jimma Ethiopia (Getahun T.et el 2011), but was supported by other study by Al-Momani (1994). Educational status of the respondents has also shown significant association with waste generation which is different from with findings of study conducted on municipal waste b generation rate in Jimma town in which educational status

of households was negatively associated with total generation rate Getahun T.et el (2011) Sujauddin et al (2008) and Afon and Okewole (2007) .

## 6.3 Percentage composition of Residential SW component

The major compositions of domestic solid wastes from the studied households were biodegradable organic wastes which constitutes 51.4 % by weight. This percentage waste is similar with what was observed in many developing countries; Nigeria, 52-65 % (Imem et al., 2008), Jordan, 54-78% (Abu-Qadir, 2007), etc. The non biodegradable organic waste components constitutes 4.2 % where as the recyclable materials constitutes 5.7 %.Plastic waste is a non-biodegradable substance and has become a common problem of the study area . This might be because of the inappropriate handling of plastic product by the consumer after they utilized for their daily purpose and the lack of any microenterprise organization in the town, which reuse or recycle even though plastic are recyclable and reused substances.

## 6.4 Percentage composition of commercial solid waste fractions

The percentage composition of commercial solid waste categories or fractions by volume showed that 70.9 % by weight was biodegradable organic wastes and 7.72 % by weight was non-biodegradable by weight where as the recyclable material constitutes 21.78 % by weight. This figure shows the presence of recyclable materials in Dukem town commercial solid waste. Generally if composting and recycling are exercised in Dukem town there is a possibility to reduce the amount of commercial solid waste going to be disposed in disposal site from Dukem town. Camille De Stoop (1998) wrote as if there is little room for profitable and viable investments as far as large-scale waste recovery is concerned. However, as can be seen from this research finding from the total solid waste generated in Dukem town there is a possibility to recover the waste through composting and recycling. Moreover, this indicates the presence the potential for resource recovery in a large scale.

During the study potentially hazardous wastes like soap, detergents, and detergents containers, perfumes, oil containers, oiled textiles and papers, cosmetics containers, oil cleaner, oil filter, break oil, dry cell, disinfectants are observed. Medical wastes like discarded or used syringes and different tablets have also been observed during sorting of commercial solid waste.

Commercial solid wastes produce hazardous waste related to the service they provide: for example, solvents from photographic and dry cleaning shops, cleaning solvent from auto repair

Garages, ink from printing shop, paints and thinners from hardware shops (Girma Kebede 2004). According to the data obtained from the municipality office and authors personal observation in Dukem, town "Chat" is recently highly used by the populations and new comer to the town and so that "Chat" wastes, dramatically promote the proportion of these solid wastes.

The major source of dust in Dukem Town is due to the high construction activities and the constant movement of vehicles. Besides, sometime in the year, the windy nature of the weather condition aggravates dust to blow to the air and later on settle in the ground. Similar trend was observed in Jimma town; according to the Jimma town master plan revision project study in 2004, the major sources of dust are flooding and soil transportation from nearby catchments, construction of road network, quarrying activities under taken in the town, establishments like woodworks, shops, coffee processing plants etc, produce dust in their production process.

### 6.5 Proximate and ultimate analysis

From proximate and ultimate analysis, the result shows the presence of possibilities to generate more energy from commercial solid waste and C and N ratio testifies the possibility of making compost from this source for fertilizer. So that, this is a good opportunity for Dukem town, since solid waste disposal site is the problem.

### 6.6 Sources of energy

Sources of energy of most households are wood, charcoal, kerosene, cow dung, paper, yard trimmings, etc. Electric power for most families, if they have access to the services, is only for lighting purpose. This is due to lack of capacity to afford the installation costs and service charges. Significant number of housing units are not legally registered (illegal houses i.e. Yechereka Bet), that they cannot get direct service from EEPCO. Hence, householders build their kitchen in such a way that it could serve them with the help of the above mentioned energy sources. Some even have no kitchen at all. They cook their daily meal on open area at their home sides or inside their living rooms. In Dukem town most of the households use Charcoal , wood, dung, paper and kerosene in addition to electricity for their source of energy. Therefore, ash is a common solid waste in the majority of households.

### 6.7 Onsite Solid Waste handling

Onsite waste handling refers to the activities related to the handling of solid wastes until they are

placed in the containers used for their storage before collection. Depending on the type of collection service, handling may be required to move the loaded containers to the collection point and to return the empty containers to the collection point where they are stored between collections (Tchobanoglous et al., 1993).

Factors that must be considered in the onsite storage of solid wastes include type of container, container location, collection methods, frequency of cleaning houses, etc. Onsite storage is of primary importance of the aesthetic consideration, public health and economics involved. Unsightly containers and even open ground containers are undesirable and often seen in residential areas (Tchobanglous et al., 1977).

Regarding solid waste storage, the result above shows that most household's uses trash bag for their temporary waste storages. This is because it is longer lasting than plastic bags. Other households uses materials like baskets, metal buckets, plastic containers and open dumping at their home sides, as their temporary waste storage. This clearly indicates that the waste storage system of the town is not convenient.

According to this study, some households burn their combustible wastes to get rid of uncollected wastes. Sometimes, they do so to reduce the volume of the wastes that would cause them to pay high charges for pre-collections.

## 6.8 Solid Waste collection and Disposal practices

Waste collection service in Dukem town has given by municipal solid waste management office. However, the survey showed that little coordinated activities have been done by municipality. On the other hand, in some neighborhoods containers are placed, but not enough still other simply dump on the open field. According to some surveys estimation, a household should get a container within 200 meters of his vicinity (Yami, 1999), and one container provides services to a maximum of 2000 people. Based on this estimation only 28 (25.2%) of the households are found within the service area of the container. During the interview, there were respondents who stated that there is no enough collection services in the town. The survey indicated that, this is due to the unable to budget for collection of solid waste and location of the houses or due to inaccessibility roads.

Waste disposal is one of the most important management activities, which needs to be carefully planned. With regard to waste disposal at transfer station, the study identified that almost all solid waste generated in households is disposed together that is there is no sorting habit of organic waste at the household level. Huge amount of organic materials comes from the rural areas depraving nutrients from the rural soil to feed the urban population, the leftovers after consumption have no way to return to the source to build the soil, rather lost and create problems to human health and the surrounding environment in the city due to mismanagement. Different studies described that this waste is creating health and environmental problems in Addis Ababa, where there is no proper waste Management (Tamiru 2003). Similarly, 74.6% of respondents in the study area indicated that they burn organic waste together with the other solid waste , The respondent these days monitoring is relatively weak because absence of penalty for mismanagement of solid waste; thus. People preferred to dump waste anywhere instead of carrying waste to pre collection sites, which are far from most households. On the other hand, the survey showed that nobody is responsible for the waste dumped on roadside**.** The rest remains piled in the ditch and on its ways.

## CHAPTER SEVEN

# CONCLUSION AND RECOMMENDATIONS

## 7.1 Conclusion

It is highly recognized that the existing solid waste collection and disposal services are inadequate both in terms of coverage and sanitary treatment of the waste. The solid waste collection service coverage is very low which means the major portion of the solid waste generated within the city is uncontrolled and improperly disposed which creates unhealthy environment to live and work in. No condition is available for community and private sector involvement in re-use, recycle and composting of the waste. But it can create job opportunity for the unemployed citizens of the town. In general waste management is not considered as important development sector to meet the goals set in the national and regional policies and strategies for sustainable development.

Municipality has limitation on waste collection system. The major ways of reducing and disposing of solid wastes such as source reduction, reuse, recovery, recycling, sanitary land filling, composting and incineration were absent. As a result wastes were most often dumped on land, in the river or otherwise burned to reduce volume.

There were no awareness raising education and provision to proper training of residents with regard to residential and commercial solid waste management methods in the town. This has aggravated the waste management problems and challenges thus leading to public health, aesthetic and ecological concerns.

From the study results, large proportion of the waste is decomposable organic matter, which might be efficiently recycled or composted.

## 7.2 Recommendations

As mentioned earlier, the municipality has limitation on waste collection system. To improve this, the following recommendations are suggested:

- The municipality has to capacitate "the Health and Environmental Sanitation Section" with relevant skill manpower and equipment both qualitatively and quantitatively.
- The municipality has to incite and motivate workers who have direct contact with waste.
- The municipality shall improve awareness of the society. Wastes disposed of illegally at any open spaces are not only because of lack of nearby containers or because of lack of municipal waste collection services but also due to lack of awareness of the consequences of mismanaged municipal wastes.
- The municipality shall to reduce a waste that goes to dump site through composting wastes.

Thus based on the generation rate and composition of solid wastes in Dukem town integrated solid waste management system which combines a range of solid waste treatment options like source reduction, composting, recycling and waste to energy transformation is recommended.

In general, if the town administration improves its effort on municipal waste management system and gives due attention for the town, probably it will not be very far to see beautiful, clean, and green Dukem.

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# ANNEXES

## Annex 1:

### Definitions of terms

**Agricultural solid wastes**, Agricultural wastes and residues resulting from various urban agricultural activities-such as the harvesting of vegetables along some of the city's rivers, the Production of dairy products, and the production of small animals for slaughter- are also on the increase, these wastes are indiscriminately thrown along roadsides and waterways and in open fields. No data are available on the amounts of solid wastes generated from urban agricultural activities.

**Ash:** means a residue from the combustion of any solid or liquid material. This type does not include any subtypes.

**Commercial solid waste**s: are wastes that originate in wholesale, retail, or service establishments, such as offices buildings, stores, markets, theaters, hotels and warehouses.

**Construction solid wastes**: the composition of such wastes may include concrete, stones, bricks, blocks, scrap wood, metals, plastics, broken glasses, plumbing and electrical parts, and dirt, Wastes from torn-down houses or buildings, crumbing streets and sidewalks, and other run-down structures also contribute to the growing volume of solid wastes in the city.

**Food waste:** means food material resulting from the processing, storage, preparation, cooking, handling, or consumption of food. This type includes material from industrial, commercial, or residential sources.

**Leaves and Grass:** means plant material, except woody material, from any public or private landscapes.

**Municipal solid waste** : more commonly known as trash or garbage consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries.

**Residential solid wastes:** contain putrescibles (rapidly decomposing) animal and vegetable matters resulting from the handing, preparation, cooking and consumption of foods, paper, cardboard, textiles, leather, wood, tin cans, yard wastes, grass, ash, and dirt. In addition, there are bulky household wastes, especially from well-to- do household, such as old furniture, appliances, and electronic gadgets.

**Sewage Solids**: means residual solids and semisolids from the treatment of domestic waste water or sewage. This type does not include any subtypes.

**Solid Wastes:** means any Garbage, refuse, sludge, and other discarded solid materials, including solid waste materials resulting from industrial, commercial, and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage or other significant pollutants in water resources.

**Special Waste**: Ash, Sewage Solids, Industrial Sludge, Treated Medical Waste, Bulky Items, Tires, Remainder/Composite Special Waste.

**Textiles** means items made of thread, yarn, fabric, or cloth.

# Annex 2:

## QUESTIONNAIRE

1. Demographic, social, and economic data

1.1 Name of the household _____

1.2 Kebele _____

1.3 House No._____

1.4 Age _____

1.5 Sex_____

1.6 Family size _____

1.7 Family income /Month (please made circle)

a) <400,

b) 401-900,

c) >900 Birr

1.8 Educational Status of the household

a) primary

b) secondary

c) certificate

d) diploma and above

2. Housing

2.1 ownership

a) Private

b) Rented

c) Government

2.2 Cleanliness of the house/compound

a) Dirty

b) Attractive

c) Absolute Clean

2.3 Source of energy (made circle)

a) Firewood

b) Cow dung

b) Charcoal

c) Kerosene,

d) Electricity

If others specify_____

3. Solid Waste Handling time schedule

3.1 How often you clean your house (made a circle).

a) Every day

b) Every two days

c) Every week

Others, Specify _____

3.2 Do you have temporary storage container?

a) Yes

b) No

3.2.1 If yes, type of container? (Make a circle)

a) Plastic Dust Bin

b) Plastic Bag

c) Concrete container

d) Metal container

Others, specify _____

3.2.2 Is the container covered well?

a) Yes

b) No

4. Solid Waste Disposal activities

4.1 Do you reuse household wastes?

a) Yes

b) No

4.1.1 If Yes,

Kinds of reused wastes _____

4.2 Do you compost wastes?

a) Yes

b) No

4.2.1 If yes, what type of wastes? _____

4.3 Do you burn household wastes?

a) Yes

b) No

4.3.1 If yes what type of wastes? _____

4.3.2 Where do you burn?

a) Inside the compound

b) Outside the compound

4.4 Do you use open dump as method?

a) Yes

b) No

4.4.1 If yes, where do you dump? (Make a circle)

a) Inside the compound

b) Outside the compound

c) In both compound

4.4.2 What type of waste do you dump?

a) All type

b) Only organic waste

c) Only inorganic waste

d) Only solid waste

4.4.3 How far is the container from your home?

a) 25-54 meters

b) 55-110 Meters

c) 111- 215 Meters

d) 212-515 Meters

f) > 517 meters

4.4.4 What mechanism do you use to transport wastes to containers?

a) By hands

b) Hand pushed carts

c) Horse drawn carts

d) Others specify_____

4.5 Do you dump solid waste into the nearby river?

a) Yes

b) No

4.5.1 If yes, why? _____

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

a) Yes

b) No

If yes, who? _____

6. Is the existing waste management of the municipality satisfactory?

a) Yes

b) No

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

_____

_____.

7. If you have any suggestion about controlling of MSW of Dukem Town

_____

# Annex 3:

**CHECK LIST ABOUT DUKEM TOWN.**

1. Is there municipality service for managing the MSW?

   a) Yes

   b) No

1.1 If yes, specify the organization _____

2. Is there any landfill sites in Dukem town?

3. How many landfill sites Dukem town have? _____

4. How far are/is the landfill site(s) from the town in km? _____.

5. Is the landfill site protected?

   a) Yes

   b) No

4. Are there street cleaning organizations in the town which are organized by the Municipality?

   a) Yes

   b) No

4.1 If yes, their number.

Male_____

Female_____

Total_____

5. Are their Micro Enterprises organized in the town for collecting solid waste?

   Yes

   No

   If yes, Please list names of MSE and their numbers;

| Name of MSE | Male | Female | Total |
|---|---|---|---|
| A. _____ | | ____ | _____ |
| B. _____ | | ____ | _____ |
| C. _____ | | ____ | _____ |

Total _____ _____

6. How many containers are there in the town? _____

7. How is the distribution of the containers in each kebele _____

8. How many lifting tracks Dukem town has? _____ is it functioning by now.

a) Yes

b) No

8.1 If No, what means does the municipality use? _____

_____

8.2 Are there NGOs or any organization who support the municipality to control or to lift solid waste ?_____

9. Duration of the tracks emptying the containers

- Every day
- Every other day
- Once in 3-5 days
- Once per week

11. Is there a river crossing the town?

a) Yes

b) No

11.1 If yes, is any controlling mechanism that people not to dump in it? _____

_____

12. What types of solid wastes are common in

♦ Dry season _____

♦ Rainy season _____

13. Does the municipality practiced to create awareness about SW and its positive and negative consequences to the community?_____

14. What actions does the municipality take on individuals who improperly dispose Waste?_____

_____

15. Do you think existing financial, technical, material, and manpower support for the control of MSW of Dukem town satisfactory?

a) Yes

b) No

16. If no, in your opinion, what must be done to improve solid waste management of Dukem Town? _____

_____