



ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY
OFFICE OF GRADUATE STUDIES

THE SOLID WASTE GENERATION RATE AND DISPOSAL
MECHANISM IN ADAMA CITY, ETHIOPIA
A THESIS

Submitted to the Department of Applied Biology
School of Applied Natural Science

In Partial Fulfillment of the Requirement for the Degree of
Master's in Biology

BY

Fitawrari Negesso Warisso

Adama, Ethiopia
September 2017

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

OFFICE OF GRADUATE STUDIES

THE SOLID WASTE GENERATION RATE AND DISPOSAL

MECHANISM IN ADAMA CITY

A Thesis

Submitted to the Department of Applied Biology

School of Applied Natural Science

In Partial Fulfillment of the Requirement for the Degree of master's in

Biology

BY

Fitawrari Negesso Warisso

Advisor: Dr. Yeshiemeбет Major

Adama, Ethiopia

September, 2017

Approval of Board of Examiners

We, the undersigned, member of the Board of Examiners of the final open defense by Fitawrari Negesso Warisso have read and evaluated his thesis entitled `` The Solid Waste Generation Rate and Disposal Mechanism in Adama City, East Shoa Zone, Oromia region, Ethiopia `` and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the degree of master's of science in Biology.

----- Supervisor/Advisor	----- Signature	----- Date
----- Chairperson	----- Signature	----- Date
----- Internal examiner	----- Signature	----- Date
----- External examiner	----- Signature	----- Date

Declaration

I hereby declare that this MSc Thesis is my original work and has not been presented for degree in any other University, and all sources of material used for this thesis have been duly acknowledged.

Name: Fitawrari Negesso Warisso

Signature: -----

This MSc Thesis has been submitted for examination with my approval as thesis advisor/supervisor.

Name: -----

Signature: -----

Date of submission: -----

Supervisor's /Advisor's Approval Sheet

To: Biology department

Subject: Thesis Submission

This is to certify that the Thesis entitled

“ The solid waste generation rate and disposal mechanism in Adama city ” submitted in partial fulfillment of the requirements for the degree of master's of science in Biology, the Graduate program of the department of Applied Biology and has been carried out by Fitawrari Negesso Warisso Id. No. GSU/0001/08, under my supervision. Therefore, I/we recommend that the student has fulfilled the requirements and hence hereby he/she can submit the thesis to the department.

Name of major Advisor/supervisor: -----

Signature: -----

Date: -----

ACKNOWLEDGEMENTS

My first and foremost gratitude is forwarded to my advisor Dr. Yeshiemebet Major for her close guidance, critical comments, corrections, assistance and encouragement in the preparation of this research paper.

I wish to acknowledge the help and support given to me by different institutions such as Adama science and Technology University, School of applied natural science, Department of Biology and Eastern and Central Oromia Meteorological Service Center.

I would like to express my appreciation and thanks to workers of sanitation, beautification, and parks development of Adama city department. Moreover, all respondents who were kind to cooperation and willing to give genuine information for preparation of the main body of this study. Lastly, I would like to address my deepest thanks to my parents and friends for their moral and material support.

List of Abbreviations and Acronyms

CFR	Code of federal regulation
EPA	Environmental protection Authority
EPHTI	Ethiopian public health training initiative
HHs	Households
ISWM	Integrated solid waste management
MSEs	Micro and small-scale enterprises
MS	Municipal solid
MSW	Municipal solid waste
PAN	Practical action Nepal
3Rs	Re-use, recycle and resource recovery
SPSS	Statistical package for social science
SW	Solid waste
SWM	Solid waste management

Table of Contents

Page

ACKNOWLEDGEMENTS	i
List of Abbreviations and Acronyms.....	ii
List of tables	vi
List of Figures.....	vii
Abstract.....	ix
1. Introduction	1
1.1 Background of the study.....	1
1.2 Statement of the problem.....	2
1.3 Objectives of the study	2
1.3.1 General objective.....	2
1.3.2 Specific objectives	2
1.4 Research questions	3
1.5 Significance of the study	3
1.6 Scope of the Study.....	3
2. Literature Review	5
2.1 General condition of solid waste	5
2.2 Sources of solid waste	6
2.3 Characteristics of municipal solid wastes.....	10
2.4 Solid waste management systems.....	11
2.5 Mechanism of solid waste disposal	12
2.6 Policy options for urban solid waste management	13
2.6.1 Developing meaning full partner ships with private sector, informal workers and communities for effective implementation of ISWM.	13
2.6.2 Reducing MSW and aiming for “zero wastes”	15
2.6.3 International Partnership for Expanding Waste Management Services of	15
2.6.4 Increasing reuse and recycling of resources.....	15
2.6.5 Effectively managing specific types of waste streams such as organic wastes, E-wastes, constructional wastes.....	16

3. Materials and Methods	18
3.1 Description of the study area	18
3.1.1 Temperature	19
3.1.2 Rain fall	19
3.2 Research Design	20
3.3 Sampling method and sample size determination	21
3.4 Stratification of the study area.....	22
3.5 Sources of data.....	22
3.6 Identification of households	23
3.7 Data gathering instruments.....	23
3.7.1 Questionnaire	23
3.7.2 Interview.....	24
3.7.3 Direct Observation	24
3.8 Procedures of data collection.....	24
3.9 Methods of data analysis	24
4. Results and Discussion	25
4.1 Characteristics of households	25
4.2 Generation of solid wastes within source type	26
4.3 Types of solid wastes mostly generated from the city.....	28
4.4 Secondary solid waste storage facilities and handling	30
4.5 Engagement of MSEs Employees in the solid waste collection activity.....	31
4.6 Collection system and working condition	32
4.7 Unsafe and safe SW disposal Activities	33
4.8 Transportation and storage of collected waste	34
4.9 Types of working tools and equipment	35
4.10 Accessibility of health and safety protection materials	35
4.10.1 Health risks for waste pickers and communities.....	Error! Bookmark not defined.
4.11 Attitude of community (households) towards waste collectors.....	36
4.12 Household Roles.....	36
4.13 MSEs Officers' role in supporting the micro and small scale enterprise	37

4.14 Constraints and problems of enterprises	39
4.15 Factors affecting activities of solid waste employees in the area	40
4.15.1 Lack of recognition	40
4.15.2 Equipment	40
4.16 Household view towards solid waste collectors	41
4.17 Solid waste collection & disposal operation.....	41
4.17.1 Primary Collection	41
4.17.2 Secondary Collection	41
5. Conclusions and Recommendations	41
5.1 Conclusions	42
5.2 Recommendations	43
6. REFERENCES	45

List of tables	Page
Table 1:- Different sources and types of solid wastes (Source; EPHTI, 2004).....	8
Table 2: Representative selected kebeles of Adama city and number of sampled HHs.....	22
Table 3: Distribution of respondents by sex, education and religion.....	25
Table 4: Solid waste generation and their respective sources.....	26
Table 5: Solid waste generation rate per the selected HHs.....	27
Table 6: Solid waste generation per randomly selected kebele	28
Table 7: Physical composition of solid wastes in Adama city.....	29
Table 8: Frequency of SW collection system in Adama city.....	32
Table 9: Types of SW disposal methods in practice in Adama city	33
Table 10: Types of transportation system	34
Table 11: Types of secondary storage areas of solid wastes	35
Table 12: Health and hygiene protection materials	35
Table 13: Attitude of household towards waste collectors	36
Table 14: The HHs response about the role of MSEs in collecting solid wastes.....	36
Table 15: The role of MSEs Officers of the kebeles in supporting the MSEs.....	37

List of Figures

	page
Figure 1:- Solid wastes preference.....	12
Figure 2:- Waste hierarchy (clean away, 2010).....	16
Figure 3:- map of the study area	18
Figure 4:- Minimum and maximum temperature of 2012-2016 of Adama city.....	19
Figure 5:- Adama city average rainfall from 2012 -2016 years.....	20
Figure 6: employ driving factor to work on solid waste collection activities	31
Figure 7: Unsafe disposal within socio-economic level of households	34
Figure 8: Koshe or Raphe solid waste disposal (Addis Ababa, Ethiopia).....	45
Figure 9: The solid waste illegally disposed around Gimb (kebele 05).....	45
Figure 10: Solid waste illegally disposed around kebele 08, which is causing unpleasant odor.	46
Figure 11: Unsafely disposed solid waste filled the canal around kebele 11.....	46
Figure 12 Solid wastes illegally disposed, which is causing bad smell around old bus station.	47
Figure 13: SW collected and left near to the old railway for long time by MSEs in kebele 14.	47
Figure 14: Solid waste over flowing the container around Abyssinia bank of kebele 05.....	48
Figure 15: Push carts used by solid waste collectors in kebeles 14 (transfer station).	48

List of Appendix	page
Appendix I	52
Appendix II	57
Appendix III.....	58
Appendix IV	61

Abstract

The problem of solid wastes is increasing day by day with growing urban population coupled with economic growth and this in turn is posing serious problem to municipalities, in terms of collection and disposal of solid waste. The overall purpose of this study was to assess the solid waste generation rate and disposal mechanism in Adama city, Ethiopia. The study was conducted from September 2016 to June 2017. Descriptive survey study design was employed for the study, and both quantitative and qualitative methods were used to collect data. The data were gathered from four Kebeles of 192 randomly selected households, using open ended and close-ended questionnaire, purposely-selected key informants using semi-structured interview and these were supplemented with field observation. The results of the study revealed that most of the respondents had low awareness towards safe solid waste management and the solid waste collectors. The generation rate was 0.367 d/cap/. The study showed that only 26.98% of the households had access to waste collection and transportation services, which indicates that the city municipality is under capacity to provide waste collection and transportation service. 98% of the respondents reported that recycling was not being practiced in the city. Therefore, the potential of recycling and reusing activities are yet to be exploited. About 73% of the urban dwellers dump the waste dispose illegally and there exists no well-designed dumping or landfill site, consequently urban dwellers were vulnerable to surface and groundwater pollution and water flooding. Urgent and immediate improvement in building the capacities of the municipality is necessary to meet the current demand for improved municipal waste management and a number of recommendations are made aimed at improving the municipal solid waste management system.

Keywords: Adama, Ethiopia, people awareness, Safe waste disposal, Solid waste management

1. Introduction

1.1 Background of the study

Solid wastes are all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. The rapid urbanization that has been taking place virtually transformed the world into communities of cities and towns facing 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 an unavoidable and critical issue both in developed and developing nations. Solid waste management is defined as the collection, transportation, processing, recycling, and disposal of solid waste materials to reduce their effect on health, environment and aesthetics. It is highly related with urbanization and industrialization (UNIDO, 2001).

Similarly, the current condition of municipal solid waste management service in different towns of Ethiopia is also becoming a challenge for municipalities. In Adama, illegal dumping of waste on open areas, in gullies, river courses is considered as routine task of residents. The efforts made by the municipality to change the situation in the city are also insufficient as it compared to the extent of the problem. Therefore, in order to reduce this situation and achieve efficient solid waste management system of the city, detail study of the existing condition of municipal solid waste management service is required

In urban centers throughout African region, less than half of the solid waste produced is collected. Moreover, 95 percent 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 (Mohammed *et al.*, 2012). Only 50 to 60 percent of the waste generated in urban areas in Africa is collected, while 40 to 50 percent of the waste remains uncollected in the street (WHO, 1996).

In Ethiopia, micro and small-scale enterprises involvement in solid waste management as a formal sector started in 2003/2004 at Addis Ababa (Fanta *et al.*, 2006). The service was expanded to other cities with the formulation of a national solid waste proclamation in 2007. The proclamation states the advantages of linking the community in solid waste management in order to prevent adverse

effects, and to enhance the benefits resulting from solid wastes, thereby promoting it as a source of investment. Thus, anyone who wants to be engaged in solid waste management should get legal permission from the respective urban administration. Despite this, there are many challenges in the implementation of the proclamation and hence, an extremely low level of returns has been obtained from efforts put into dealing with SW. With the increasing amount of SW in Adama, the city administration is unable to manage the SW generated from households and different organizations. In general, the current SWM practice in Adama could not cope with the fast urbanizing needs of the city.

1.2 Statement of the problem

Increased urbanization and population growth in Adama city has led to a series of problems such as increased generation of waste, inadequate collection, transport and disposal of solid waste. People dispose their waste illegally in open fields, streets and ditches. The city faces problems like scattered solid wastes here and there in the city, illegal disposal of solid wastes and the likes.

Ditches are filled with solid waste disposed by inhabitants causing flood in the city, and refuse often blocks drainage channels causing ponds often polluted with organic waste because which domestic flies and mosquitoes are breeding. Solid waste collectors were not provided with appropriate clothing and usually complain about their health problems. These problems were expected to become more evident as urbanization continues to expand in future.

In general, the current solid waste management practice in Adama city could not cope with the fast urbanizing needs of the city. Therefore, the study area selected because, the city is among the fast growing cities in the country where solid waste management problem is crucial and has many resort and recreational areas where most people prefer to pass their weekend breaks. This in turn creates additional waste burden to the city's waste management. Therefore, these factors initiated to study the solid waste generation rate and disposal mechanism in Adama city.

1.3 Objectives of the study

1.3.1 General objective

- To assess the solid waste generation rate and its disposal mechanism in Adama city.

1.3.2 Specific objectives

- To identify the solid waste generation rate of the city

- To identify the main types of solid wastes disposed in the city.
- To assess the existing status of solid waste management services of the city.
- To assess the coverage of solid waste management service of the city.
- To identify the challenges of the solid waste disposal activities.

1.4 Research questions

1. What types of solid wastes commonly disposed in the city?
2. What mechanism does the household use to dispose solid wastes safely?
3. What are the challenges of disposing the solid wastes safely?
4. How far does the municipality cover the collection and safe disposal of SW in the city?
5. What mechanism in practice used for safe disposal of SW in the city by residents or municipality?

1.5 Significance of the study

Rapid urbanization due to population growth in Adama city caused a series of problems such as increased generation of waste and inadequate collection, transport and disposal of solid waste. This has become a major threat to the urban environment and health of citizens in Adama city for a long period. Consequently, the city administration intervened into the door-to-door primary solid waste collection through institutionalizing and integrating Micro and Small scale Enterprises into the waste collection system, which was originally exclusively run by informal waste collectors (Yohanis *et al.*, 2015).

Therefore, minimizing the solid waste generation rate and its unsafe disposal activities are the significant role in controlling environmental sanitation and public health. Thus, the study will provide some information to residents, policy makers and environmental protection practitioners interested to assist financially, on job training and legal provision that in turn minimize the problem of solid waste generation rate and its disposal. The study could also help as background information for those researchers who want to do further study.

1.6 Scope of the Study

Municipal solid waste management encompasses all waste streams from various sources such as households, commercials, institutional etc. It also comprises of all activities including waste generation rate and composition, waste collection, storage, transfer, waste processing,

transportation and disposal. Since it was difficult to cover the whole aspect of SWM activities within the available time and resources, the study is limited only to assess solid waste generation rate and its disposal mechanism in Adama city.

2. Literature Review

2.1 General condition of solid waste

Solid wastes are all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. The term solid waste as used in this text is all-inclusive, encompassing the heterogeneous mass of throw aways from the urban community as well as the more homogeneous accumulation of agricultural, industrial, and mineral wastes. Because of their intrinsic properties, discarded waste materials are often reusable and may be considered as a resource in another setting (Takele, 2004, a).

Solid waste is material, which is not in liquid form, and has no value to the persons who is responsible for it (Zurbrugg, 2003). Or waste may be solid or semi-solid materials, resulting from human and animal activities, that are useless, Solid unwanted, or hazardous (Tefera *et al.*, 2015). From the days of primitive society, humans and animals have used the resources of the earth to support life and to dispose of waste. In early times, the disposal of human and other waste did not pose a significant problem, for the population that was small and the amount of land available for the assimilation of waste was large. Problems with the disposal of waste can be traced from the time when humans first began to congregate in tribes, villages, and communities and the accumulation of waste become a consequence of life (Techobanaglou *et al.*, 1993).

Similarly, solid wastes mean any garbage, refuse, sludge, and other discarded solid materials. 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. Code of Federal Regulations part 243, 1995).

In Ethiopia according to the Federal Democratic Republic of Ethiopia Proclamation No.513/2007, (2007) Solid Waste Management Proclamation “Solid Waste” means anything that is neither liquid nor gas and is discarded as unwanted. These could be refuses from residential, commercial, or any institutes as yard sweeping, food remains, ash and chat leftover, saw dust, piece of wood, papers, glasses, metals, batteries, plastic, grass and vegetables, bone of animals, dead animals and other materials that cause poor environmental situation. The sources of solid wastes are residential,

commercial, institutional, construction and demolitions, municipal services, industries, mining, and urban agriculture (Juhasz *et al.*, 2004).

2.2 Sources of solid waste

From the foregoing urban waste classifications, it is evident that different categories of waste may require different handling, collection and disposal equipment. In terms of proportions, household waste accounts for usually up to 75 percent of all the municipal solid wastes. The four categories of waste that comprise the largest proportions are household, commercial, institutional and street wastes, which together are termed municipal solid wastes. Small quantities of construction and demolition debris are often generated by refurbishment or small alterations in houses and these wastes are often mixed with household wastes, sometimes causing significant problems because their density is so much more than household waste. At the other extreme, waste from tree pruning usually has a very low bulk density and occupies large volumes (UN-HABITAT, 2010).

The materials that are collected under the term solid waste include many different substances from a multitude of sources. The sources of solid wastes are dependent on the Socio-economic and technological levels of a society, for small rural community in Ethiopia may have known types of solid waste from known sources.

In all cases as Takele (2004, b) stated the following sources as universal:-

Household waste: In developing countries, up to two-thirds of this category consists of organic kitchen wastes. The balance is composed of sweepings, rags, paper and cardboard, a small but growing percentage of plastic and small proportions of glass, rubber, leather, bone and metals. In poor neighborhoods, traditional cooking can also produce ash, and where sanitation facilities are limited, the waste might include faecal matter. In wealthy countries discarded furniture, used appliances and garden wastes are included.

Commercial waste: In developing countries, markets are an important source of commercial waste, much of it biodegradable. Other sources come from shops, offices, restaurants, warehouses and hotels. While some large offices or hotels arrange for private collection of their wastes, most of the commercial waste continues to be handled by municipal authorities. Shops often discard large

numbers of cardboard boxes, which quickly fill communal waste containers unless the boxes are flattened or taken for recycling.

Institutional waste: Solid wastes from schools, governmental offices, hospitals, and religious buildings are included in this category. Paper is the predominant waste from most institutional sources except those containing residences, such as barracks and nurses' hostels, where the proportion of food waste is significant. Wastes from hospitals and other health care establishments should be segregated into two main categories, hazardous and general. Only the non-hazardous (general) wastes are the responsibility of the municipal authorities. Waste collection from institutional premises often entails the use of a different collection method to that used for households because of the large quantities that are generated.

Street sweepings: Street sweepings consist of sand, stones, spilled loads and debris from traffic accidents, as well as paper and plastic litter dropped by pedestrians and from vehicles or blown by the wind. They may also include appreciable amounts of household refuse and human and animal faecal matter (Table 1).

Pollution is not directly transferred from land to people, except in the case of dusts and direct contact with toxic materials. Pollutants deposited on land usually enter the human body through the medium of contaminated crops, animals, food products, or water. Land pollution can also damage terrestrial ecosystems, resulting in the deterioration of the conservation and amenity value of the environment (Medina, 2002).

Table 1:- Different sources and types of solid wastes (Source; EPHTI, 2004)

No	Source	Typical solid waste generator	Types of solid wastes
1.	Residential	Single and multifamily dwelling	Textiles, wood, glass, metals, ashes, and household hazardous wastes, Food waste, paper, card board, plastics,
2.	Industrial	Light and heavy manufacturing, fabrications, construction site.	Housekeeping wastes, packaging, food wastes, construction and demolition Materials, ash
3.	Commercial	Stores, hotels, restaurants, Markets, office buildings	Paper, cardboard, plastics, wood, Glass, food waste, special wastes.
4.	Institutional	Hospitals, prison government Center	Similar to commercial
5.	Construction and demolition	New construction sites, Road repair, demolition of Buildings, renovation site.	New construction sites, Road Repair, demolition of Buildings, Renovation site.
6.	Municipal services	Street cleaning, beaches, Land scarping, parks and other recreational areas.	Industrial prose wastes, scrap materials, Off-specification product, slag tailings.
7.	Prose	Heavy and light manufacturing, refineries, power Plants, chemical plants.	Industrial prose wastes, scrap materials, Off-specialization product, tailings
8	Agriculture	Crops, orchards, vineyards, dairies, feedlots farms	Spoiled food wastes, agricultural wastes, Hazardous wastes (pest sides)

According to Marshal (1995), open dumpsites are a major problem to the environment, especially on the air that the people inhale. Dumpsites emit obnoxious odors and smoke that cause illness to people living in, around, or closer to them. Dumpsites may be a source of air borne chemical contamination via off site migration of gases and the particles and chemicals adhering to dust, especially during the period of active operation of the site. In a number of community health surveys, a wide range of health problems, including respiratory symptoms, irritation of the skin, nose, and eyes, gastrointestinal problems, psychological disorders, and allergies, have been discovered, dump sites closer to residential areas are always feeding places for dogs and cats. These pets, together with rodents, carry diseases with them to nearby homesteads (Dolk, 1997).

A major environmental concern is gas release by decomposing garbage. Methane is a byproduct of the anaerobic respiration of bacteria, and these bacteria thrive in landfills with high amounts of moisture. Methane concentrations can reach up to 50% of the composition of landfill gas at maximum anaerobic decomposition (Sandra, 1995).

The incinerated solid wastes contribute to the air pollution; buried, it contributes to the water pollution problem and takes up land and space; if it is dumped at sea, it diminishes marine resources and may even wash up on beach. We have waste problem because our socio-economic system fails to take in to account some of the most basic ecological principles governing material cycles. This flow ultimately piles up and causes problems on the environment (Hasan, 2004).

Health and safety issues also arise from improper SWM. Insect and rodent vectors are attracted to the waste and can spread diseases such as cholera and dengue fever. Using water polluted by Municipal Solid Waste for bathing, food irrigation and drinking water can also expose individuals to disease organisms and other contaminants. Open dumping sites of municipal solid wastes and the wastes discharged thereby maintains a vicious cycle including these; Degrades water and soil quality, Cancer, resulted in high algal population in rivers and sea, Nausea etc. (Wentz, 1989).

As Michael (1995) listed, if sold wastes are not managed properly, there are many negative impacts that may result. Such as; the open burning of waste cause air pollution; the products of composition include dioxins which are particularly hazardous. Uncollected wastes degrade the urban environment, discouraging efforts to keep streets and open spaces in a clean and attractive condition. Polluted water flowing from waste dumps and disposal site can cause serious pollution of

water supplies. Methane (one of the main components of land fills gas) is much more effective than carbon dioxide as a greenhouse gas leading to climate changes.

The location of waste treatment and disposal facilities often has an impact on property values due to noise, dust, pollution, unsightliness, and negative stigma. The informal waste sector consists mostly of waste pickers who scavenge for metal, glass, plastic, textiles and other materials and then trades them for a profit. This sector can significantly alter or reduce waste in a particular system, but other negative economic effects come with the disease, poverty, exploitation and abuse of its workers (Wilson *et al.*, 2006).

Mustafa (1993) stated that decomposition of organic compounds by microorganisms is a common phenomenon. Most organic materials, such as food, wood products, or other remnants of plants, decay, and finally return to the environment in the form of simple compounds, such as carbon dioxide, water, or ammonia. Surprisingly, this phenomenon starts to create significant economic and environmental problems when landfills sites overflow with plastic.

2.3 Characteristics of municipal solid wastes

Municipal solid waste (MSW) is a term usually applied to a heterogeneous collection of wastes produced in urban areas, the nature of which varies from region to region. The characteristics and quantity of the solid waste generated in a town is not only a function of the living standard and lifestyle of the country or city inhabitants, but also of the abundance and type of the city, regions or country's natural resources.

The primary difference between wastes generated in developing nations and those generated in industrialized countries is the higher organic content characteristics of the former (Aboho, 2006). Ideally, solid waste should not contain faecal matter or urine, and law should prohibit the mixing of these materials with household wastes. However, enforcement difficulties, combined with variation in way of life, necessitate some tolerance in this matter.

Solid waste collection in a manner satisfactory with respect to environmental health is made difficult when human excretory wastes are mixed with household wastes. Handling of pathological wastes, industrial wastes, and similar materials, in association with household wastes, also should not be permitted; nevertheless, it is important to keep in mind that despite all precaution, some pathogens and chemical residues inevitably will be present in the waste (Barton, 1996).

2.4 Solid waste management systems

Solid waste management system encompasses all the activities ranging from the point of generation to disposal. Classifying these activities would help to identify and understand the problems associated with solid waste management system and give proper responses to improve the service. The functional element in solid waste management includes waste generation, waste collection, waste transportation, waste processing and recycling and finally disposal (Freiburg, 2015).

Solid waste management in urban area is complex activity that involves the collection, transfer, treatment, recycling, resource recovery, and disposal of solid waste generated in a city. The complexity of the service and the requirement of high level of organizational, technical and managerial capacity make it difficult to be handled by local governments single-handed. Therefore, effective service delivery requires cooperation between numerous stakeholders in both the private and public sectors. For successful operation, it is advisable to integrate stakeholders from the very beginning of the management phase, goal setting (Bernstein, 2004).

Likewise, effectiveness of solid waste management service is dependent on sustainability of the management of the services. Sustainability in its turn depends, among other, on the way the management of the service is planned; the institutional and financial capacity of the service providers and supporting organizations; the choice and use of technology; the private sector involvement; and community participation. Provision of effective and sustainable solid waste management service requires going even further to formulation of specific objectives and implementation of appropriate measures regarding political, institutional, social, financial, economic and technical aspects of the service (World Bank, 2006)(a).

Municipalities often discharge duties and responsibilities of solid waste management service, while tasks such as formulating legal and policy framework, setting standards and establishing the control and monitoring indicators are carried out at the national level. Frequently, challenges of decentralization such as conflicts of interests and duplication of tasks and waste of resources could be mitigated through clear definition of roles, responsibilities, legal obligations and jurisdictions. This not only serves to improve the effectiveness of the service provider, but also significantly enhances the enforcement capacity of the local governments and maximizes the satisfaction of service receivers (World Bank, 2006) (b).

2.5 Mechanism of solid waste disposal

Though waste disposal has been a matter of concern for several decades, the main problem has been taking massive proportions due to growth in population and industrialization, the two major factors that contribute to waste generation. Though some advancement is being made in waste disposal mechanisms, they are still not adequate. The challenge is to detect newer and unhazardous mechanisms of waste disposal and put these methods to use. Below are six common waste disposal mechanisms. As we go from top to bottom the preference of disposal mechanism usually decreases and land filling is the least, where as we go from bottom to top the preference of disposal mechanism increases and source reduction is most preferred one (Fig 1).

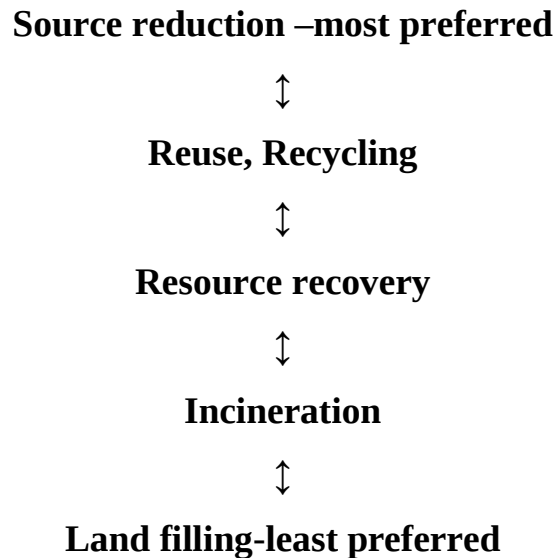


Figure 1:- Solid wastes preference

2.6 Policy options for urban solid waste management

City leaders faced with problem of decision to implement. They either continue with conventional methods of waste management or face the resulting impacts. Or they pursue an alternative path that attempts to prevent problems by adopting ISWM and 3Rs (reuse, recycle and resource recovery). To work towards the transition to more sustainable cities, city leaders should first address the existing problem by re-organizing allotment of municipal budgets to upgrade waste infrastructure and services.

The lack of an adequate policy and regulatory framework complicates matters even further. Experience has shown that the command and control approach alone cannot and will not improve waste management practices. Market-based instruments with incentives and disincentives to stimulate investments should supplement command and control. In addition, entrepreneurship was to transform waste management into an environmentally sound and socially acceptable business. Some countries lack regulations on certain waste streams such as e-waste and construction waste.

Certain countries (for example, Brazil and India) do not have formal infrastructures for recyclables collection, have only recently started legally recognizing the huge numbers of waste pickers who perform such a crucial service for the sector. By doing so, they are not only protecting and empowering the poor, but are also proceeding towards meeting relevant development goals. Therefore, cities should adopt appropriate policy options to work towards long term goals and provide an enabling framework to promote ISWM (Ministry of environment, 2010)(a).

2.6.1 Developing meaning full partner ships with private sector, informal workers and communities for effective implementation of ISWM.

A critical deficiency in waste management infrastructure has been a serious problem for many city leaders. Depending on the circumstances, a centralized approach necessitating the use of common waste management infrastructure and decentralized waste management infrastructure should be chosen. Public Private Partnerships could help implement waste management infrastructure projects that cannot be financed wholly by the city leaders.

For waste related infrastructure to be accepted by communities, it is critical to engage with the communities from the outset, to determine their needs and address their concerns with such

projects. Further, preconditions such as capital investments, future financial sustainability and institutional mechanisms should also be satisfied to ensure the proper maintenance and functioning of these facilities. Additionally, the need for “resource management infrastructure” will assume added significance in the future.

Examples of such infrastructure could include for example, product disassembly and recycling depots. In order to capitalize on the experience and knowledge of informal waste pickers, it is important to formalize and organize them and involve existing waste recycling cooperatives and waste-picker associations in the recycling activities. Once formalized, the waste pickers would receive required health-care, social security, safety equipment and dignity during their work. Micro-finance could also be provided to support entrepreneurship and recognize innovation.

Businesses in a city can come together to set up Eco Industrial Parks, where they can achieve enhanced environmental and economic performance through joint management of environmental and resource issues including energy, water, and materials. City leaders should also strengthen institutional capacity for skill development and awareness rising. Some examples of the application of this strategy include funding institutions for research into environmentally sound and safe disposal of health care waste, mining of landfills, additional study into reverse logistics and closed loop supply chain processes for resources management.

It is also increasingly evident that waste, as a sector, assumes an added complexity given the various stakeholders that are part of it. Apart from city leaders, the waste sector municipal Solid Waste Management includes a range of other key stakeholders such as waste generators, industry, financing institutions, national governments and regulators, waste technology providers, academia, NGOs, community based organizations, international finance institutions and United Nations entities. Therefore, perfecting the “right” balance with the needs and aspirations of all stakeholders becomes quite challenging.

International Partnership for Expanding Waste Management Services of Local Authorities (IPLA) that brings together stakeholders associated with waste management on a common platform for networking and knowledge sharing. IPLA is a dynamic platform for exchange of knowledge across multiple stakeholders for putting ISWM and 3Rs (re-use, recycle and resource recovery) in to practice.

2.6.2 Reducing MSW and aiming for “zero wastes”

Policy instruments such as “volume based fees” for solid waste collection could lead to reduction of MSW generation. Cities striving to reduce their wastes should set clear indicators or quantifiable measurements that reflect the performance of the cities with regard to solid waste management. Indicators should be compared against targets in order to gain a reference point for whether the action being assessed was successfully implemented and to what degree. Some examples of indicators include resource efficiency, recycling rates and amount of waste landfilled (Ministry of Environment, 2010, b).

2.6.3 International Partnership for Expanding Waste Management Services of

Local Authorities (IPLA)

IPLA is an international waste management network created to address the gaps in urban waste management due to weak capacities of city leaders. IPLA has been created to enable networking the City leaders across the world, stressing on the link between waste and resources. Moreover, aiming to connect all key stakeholders through knowledge networks, following the principles of ISWM and 3Rs. The mission of IPLA is “to share knowledge, communicate across national boundaries and work to spread best practice in order to accelerate the uptake of waste related infrastructure and services at various stages of waste management such as avoidance, prevention, minimization, separation, collection, transport, recycling, recovery, reuse treatment, and finally disposal”.

IPLA was endorsed at the intercessional conference on building partnerships for moving towards zero Waste held on 16-18 Feb 2011 in Tokyo, Japan. The Asian Institute of Technology in Thailand was chosen to be its global secretariat. Since the conference, there has been a worldwide expression of strong interest to join IPLA. More than one hundred partners, including cities and local governments, have officially registered with IPLA.

2.6.4 Increasing reuse and recycling of resources

Cities should strive to reconfigure businesses and infrastructure to deliver better returns on natural, human and economic capital investments, while at the same time reducing, extracting and using less natural resources, creating less waste and reducing social disparities. By promoting reuse and recycling of resources to displace virgin inputs for manufacture of a product, city leaders can ensure

resource savings. Citizens have an important role to play in separating waste at the source in order to facilitate collection of waste streams.

It is important to promote recycling businesses, as they have also long been known to be a substantial job provider to various sections of society. Reducing generation, promoting reuse and recycling of wastes reflects the concept of balancing environmental conservation and economic growth through the effective use of municipal Solid Waste Management of resources. City leaders should enforce market instruments such extended producer responsibility to ensure that producers take responsibility for recycling products. The rates of recycling in cities can be increased by establishing recycling facilities in collaboration with the private sector.

2.6.5 Effectively managing specific types of waste streams such as organic wastes, E-wastes, constructional wastes.

Policies should address special waste streams such as organic waste, construction and demolition waste, e-waste and end-of-life vehicles. City leaders need to adopt specific acts and regulations with strong enforcement mechanisms to govern their end-use. Waste streams that require urgent attention such as non-biodegradable waste should be identified and measures should be taken to put the appropriate technology in place to manage them and derive economic value. In the case of organic waste streams that constitute a major portion of MSW, subsidies may be offered for adopting proven locally available technologies. Special attention should be given to waste management in slums and other low-income areas and disaster-prone regions.

The waste hierarchy AVIOD

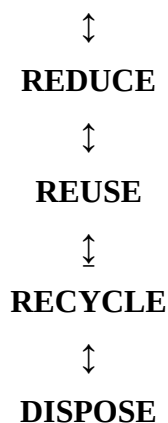


Figure 2:- Waste hierarchy (clean away, 2010)

Policies should address upstream challenges that can help support effective management downstream. For example, with growing emphasis on the green economy, sustainable production and resource efficiency, new improved forms of technology will be required to allow for sustainable design. Design for sustainability, eco-design, design for environment and Design for disassembly all refer to an approach to design, manufacture, use and disassembly that allows for easy recyclability of used products, thereby widening the scope of materials suitable for recycling. This would be included under a comprehensive policy framework encouraging reuse and recycling of special waste streams as resources (Fig 2).

3. Materials and Methods

3.1 Description of the study area

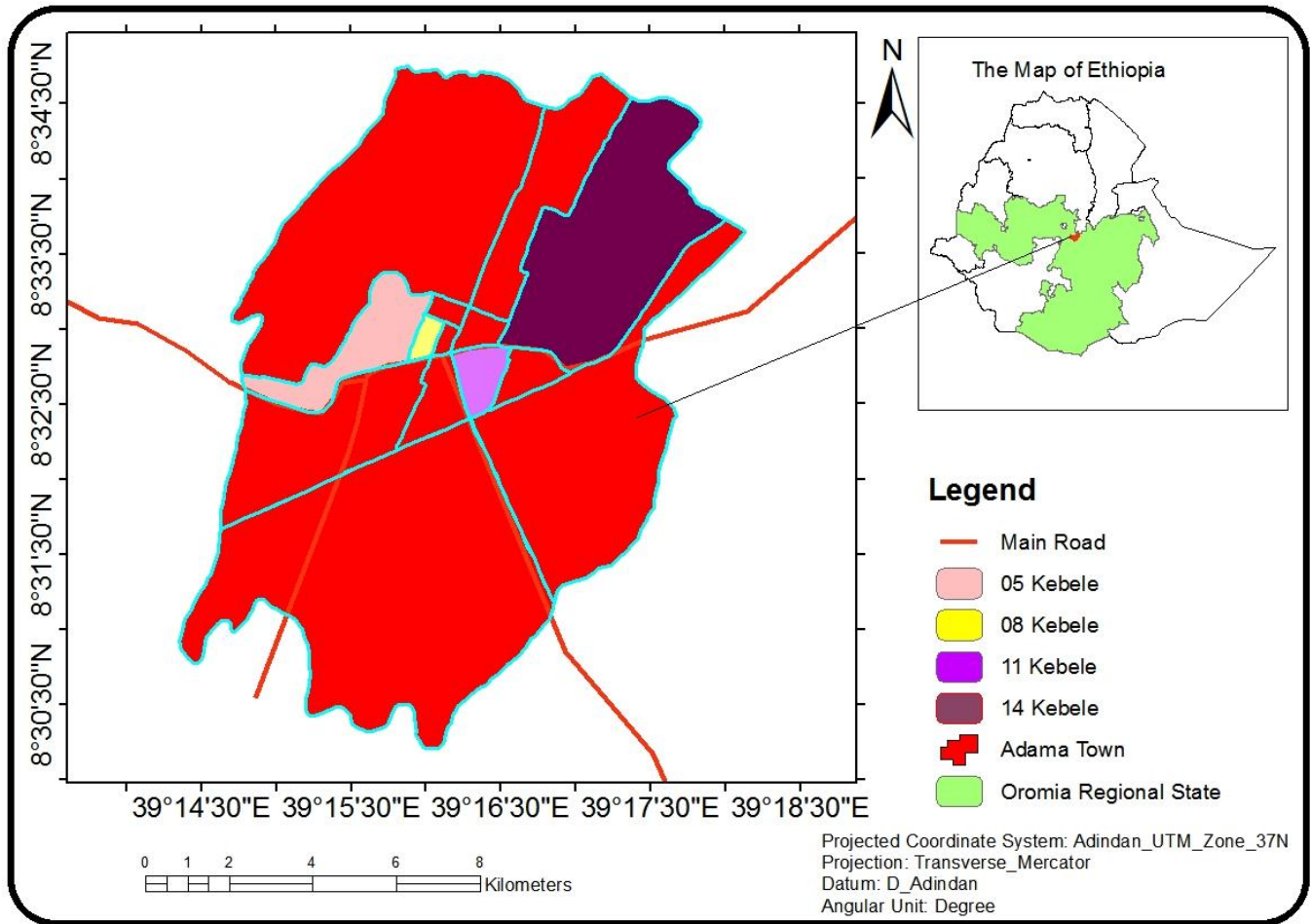


Figure 3:- Map of the study area

Adama city is about 84kms southeast of Addis Ababa. The city is found in the Ethiopian Rift Valley, at 8° 33' 21" North, latitude and 39° 17' 43" East, longitude and at an elevation of 1590-1770 meters above sea level.

Established in 1917, Adama is relatively old city by Ethiopian standards (Addis *et al.*, 2004). Regarding population it is the largest city having around 350,000 population in 18kebeles which is recently divided into 6sub cities and it has been serving as the center for different levels of administrations at varying times. In 1946, it became the seat of the Yarer and Kereyu Awraja and later in 1988, it became the seat for the East Shoa administrative region. Since 2006, Adama has been the seat of East Shoa Zone administration and Adama Woreda administration. At present, it is

serving as center for industry, trade and culture. Now the city has a status of Zonal Administration and accountable directly to the Oromia National Regional State (Fig.4)

3.1.1 Temperature

Adama is hot and the temperature varies throughout the air. Adama city has Annual mean temperature of about 22.01°C. It has minimum average temperature 19.635°C and maximum average temperature of 31°C (Fig 4).

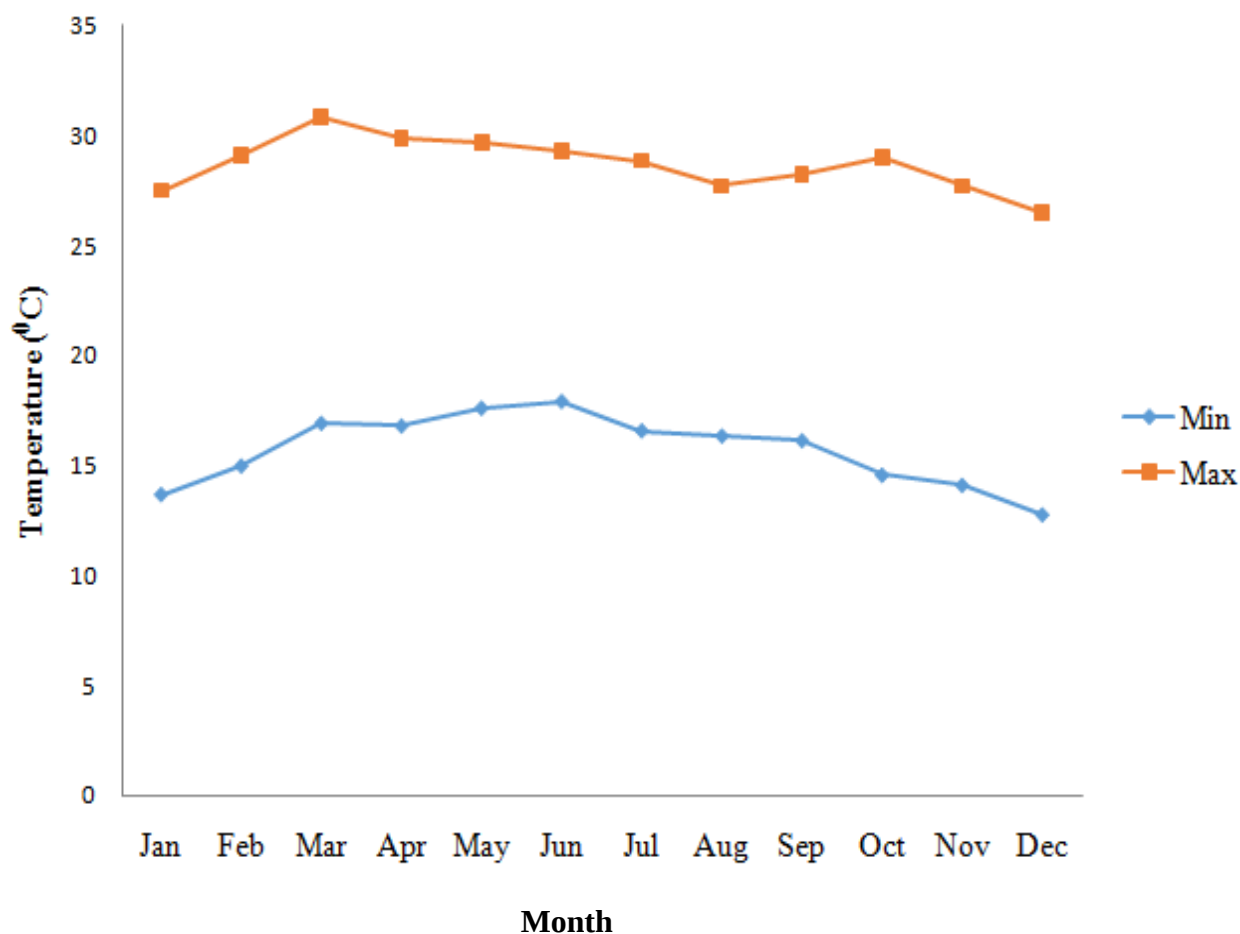


Figure 4:- Minimum and maximum temperature of 2012-2016 of Adama city.

3.1.2 Rain fall

Adama annual rainfall ranges from 6mm-210mm and average rainfall of 108mm. The dry season is during the months of December, January and February and wet season is during the months of June, July and August (Fig 5).

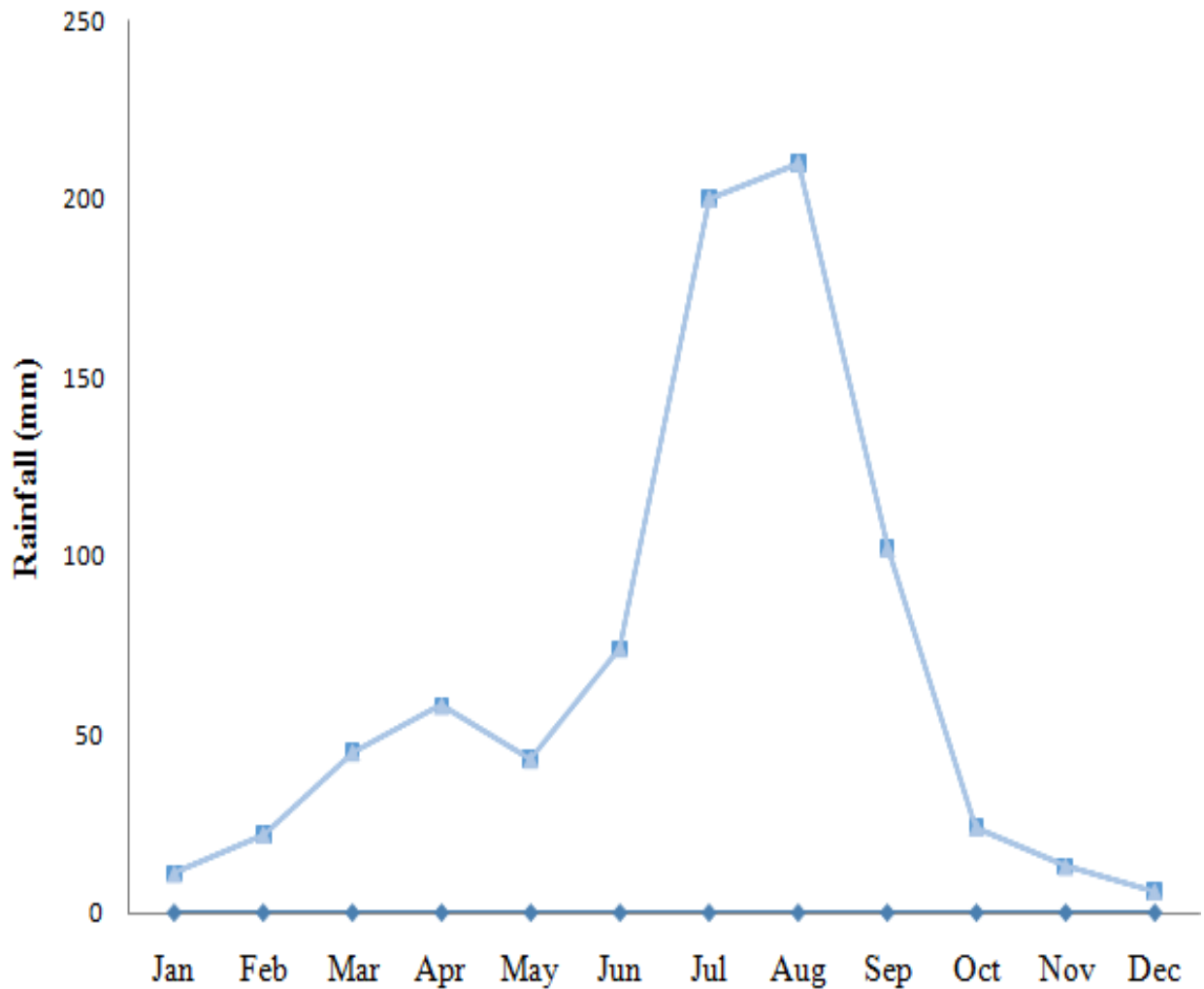


Figure 5:- Adama city average rainfall from 2012 -2016 years

3.2 Research Design

In order to achieve the intended objectives of the study, i.e. assessing the SWM system of Adama city with the special focus of solid waste generation rate and disposal mechanism, both qualitative and quantitative methods were used to answer research questions. The study was carried out from September 2016 to June 2017. Descriptive survey research method was used. Qualitative method was used to identify challenges of SWMS of the city and it was carried out by presenting, analyzing and interpreting data. Quantitative method was used to quantify generation rate.

3.3 Sampling method and sample size determination

In any sample survey, sample size determination is very important, to determine sample size of participant households, four kebeles were systematic random sampling was used. Before selecting the sample, the kebele residents who have their own home decided as study population leaving the others who are homeless and not member of the kebeles. After selection of the kebeles, each kebeles' household number arranged i.e. 05 kebele, 08 kebele, 11 kebele and 14 kebele with household number of 2340, 2560, 2900, and 2650 respectively (source:-Adama city's kebele document, 2016). Therefore, the total households of representative sample were 10450. And in determining generation rate purposive sampling was used to sample number of households from three income levels i.e. low, middle, and high-income levels.

According to data obtained from Housing Development Section of the city (2016), there are about 10450 housing units(N): out of these more than 85%(p) are of residential and the rest 15 % (Q) is for commercial activities ,offices and others. The Sample size was determined following Cochran (2016). In this case, population variable is given as:

$$n = \frac{nz^2PQ}{d^2(N-1) + Z^2PQ}$$
$$10450 \times (1.96)^2 \times (0.85) \times (0.15) / ((0.05)^2(10450-1) + (1.96)^2(0.85)(0.15))$$
$$= 192$$

Where, $n = \frac{NZ^2PQ}{d^2(N-1) + Z^2PQ}$, Sample size of housing units

P= Housing unit variable (residential houses)

Q= Non-residential houses (offices, schools, etc.) = 1-P

N= Total number of housing units

Z= Standardized normal variable and its value that

Corresponds to 95 % confidence interval equals 1.96

d = Allowable error (0.05)

In addition to 192 households, sample population taken, the officials of the MSEs Leaders and members were involved. According to the data obtained from kebele officials, there are about 24 MSEs which have a total number of about 273 employees found under the four selected kebeles out of this 10% (27) were involved as informants. Creswell (2003) states that in purposive sampling techniques the researchers purposely choose subjects who, in their opinion, are relevant to the study and the choice of respondents is guided by the judgment of the investigator.

The key informants' officials for the interview were selected using purposive sampling method from the staff of the municipality and health office workers of Adama city. This is because of the fact that the selected key informants assumed to be well aware of the problem and could provide the relevant information required for the achievement of the intended objectives of the study.

3.4 Stratification of the study area

In order to collect primary data from Adama city, the city was classified in to systematic random selected kebeles. Adama city is classified in to 18 kebeles (recently into six sub cities). In order to reduce the cost of time and energy, four kebeles were randomly selected. Namely, kebele 05, kebele 08, kebele 11, and kebele 14. The kebeles' household number were selected in the following manner (Table 2).

Table 2: Representative selected kebeles of Adama city and number of sampled HHs

Representative kebeles	No. of households	1.9% of the households
Kebele 05	2340	43
Kebele 08	2560	47
Kebele 11	2900	53
Kebele 14	2650	49
Total representative households	10450	192

The 1.9% of the households that used to design for collection of data from households on their solid waste generation rate and disposal mechanism is 192 households. Additionally to examine the institutional arrangement and capacity of the city sanitation and beautification that is responsible for city solid waste management's, institutions and factories, which generates solid wastes, were asked.

3.5 Sources of data

The data for this research were obtained from both primary and secondary sources of Adama city administration. The primary source of data was collected through questionnaire, interview and actual observation. Questionnaires open and close ended, was held mainly for households to assess their disposal system, their attitude and awareness towards waste generation and proper

management, to identify types of wastes they produce and to identify the causes of SWM problem that they are facing. A key informant interview had been made with municipality officials, kebele leaders and MSEs Leaders. It was designed to assess the current SWM system of the city, their contribution and to identify the factors that hinder them to make the city clean.

In addition, the SWM operations taking place at stakeholders, institutions, groups and individuals in Adama city were directly observed. Secondary sources of data were collected through reading and interpretation of documents, publications, annual performance reports and other related materials from city municipality library.

Forty-five respondents were interviewed from different stakeholders based on their experience and involvement in the SWM activities including households, city administration, Environmental Protection Bureau, Health Bureau and Micro and Small Enterprises (MSEs).

3.6 Identification of households

All households were stratified in to three income level groups i.e. low, middle and high-income level groups. This was done in discussion with households, kebele officials and personal observations, since there was lack of data on income level of the households. Moreover, some information was collected from different surveys of the central statistics authority.

3.7 Data gathering instruments

To collect the data three instruments were used which include questionnaire, interviews and direct observation.

3.7.1 Questionnaire

To secure data from large number of respondents, questionnaire was developed based on the basic questions in English and translated to Amharic and Afan Oromo for residents. It was also economical in terms of time and money to cover much number of respondents. Most of the questionnaires were close ended which was supplemented by few open-ended question items. The major components of the items of the questionnaire was personal and professional characteristics (background information of respondents), collection activity, participation in recycling activity, frequency and time schedule of waste collection, their income, attitude of the society, problems which were facing on their collection, future plans and government support.

3.7.2 Interview

Semi-structured interview was used for data gathering in depth on municipal solid waste management system. Interview gave the needed information orally and face to face. It was employed for leaders in the municipals of kebeles, sanitary of kebeles and MSEs.

3.7.3 Direct Observation

In order to enrich the data obtained through questionnaires and interviews and to solicit information that could not be obtained through such instruments, direct observation method was employed from October 2016 to June 2017. Moreover, it was used to validate and compare, information collected by the structured questionnaire.

3.8 Procedures of data collection

In order to get relevant and reliable information of the problems and prospects of solid waste generation rate and disposal:- first smooth relationship was created with enterprise leaders, kebele leaders and Adama city municipals so as to make them cooperative for the provision of the relevant information. In the second stage, the designed questionnaire was distributed to gather relevant data from the respondents. And the generation rate of solid wastes were collected and weighed per day, for weeks and calculated for month, year and as whole for total population of the city. In the third stage interview was conducted with enterprise leaders, leaders in Adama city administration and municipalities and officers.

3.9 Methods of data analysis

Both qualitative and quantitative techniques were used for data analysis. Quantitative methods include percentages, means, graphical, maps, ratios, rates and frequency distribution. Qualitative techniques were cause and effect relationships in which inductive and deductive reasoning were used. In addition, SPSS version 2020 was used.

The study used descriptive survey method. A descriptive survey method was selected, because the method was appropriate to describe and interpret what is there currently. In line with this, Enyew (2013) stated that descriptive method helps to have general understanding of the problem by studying the current practice, nature of the prevailing conditions and trend through relevant and precise information.

4. Results and Discussion

4.1 Characteristics of households

Table 3:- Distribution of respondents by sex, education and religion.

No.	Characteristics of respondent	Description of characteristics	Frequency	Percentage
1.	Gender	Female	40	21
		Male	152	79
		Total	192	100
2.	Educational status	Basic education	20	10
		Elementary	40	21
		Secondary school	90	47
		Higher education	42	22
		Total	192	100

As indicated in Table 3, above regarding the sex of respondents, both sexes were incorporated in the study. However, the larger proportion of the respondents was males, (79%) and the rest were females (21%). Regarding educational background majority of the society attended high school and higher education that had the capability of writing and responding correctly. The relationship between education and awareness of safe disposal of the solid waste were significant (p value = 0.029) which means as the level of education become higher, awareness of safe disposal of the respondents got better.

4.2 Generation of solid wastes within source type

Table 4: Solid waste generation and their respective sources (Adama city secondary document, 2006)

No .	Source of solid wastes	Solid waste generated averagely per a day (kg/d)	Solid waste generated averagely per annum(kg/year)	Percentage share
1.	Residential	21240	2930400	69.8
2.	Commercial area	7682	601920	14.3
3.	Street area	3868	348480	8.4
4.	Institutional	2800	252000	6
5.	Industries	1190	64800	1.5
	Total	11780	4311480	100

Municipal solid waste contains highly heterogeneous mass of discarded materials from urban residences, commercial establishments, institutions, street sweepings, and light industrial activities. Similarly, (Abebe, 2006) reported the five major sources of MSW of the city (Table 4). Based on this report i.e. the daily total solid waste generation of these sources was around 21,240kg and annually it reaches to 2,930,400Kg. This means that 69.8% of solid waste of Adama city was generated from residential areas. Therefore, the estimated or reported by Adama city municipality as solid waste generation rate was 0.224. Even if huge amount of solid waste of the city was generated from this source, the city municipality did not give much attention for it in planning and implementation process of MSWM.

Therefore, the daily and annual generation rate of household solid waste of the city was much greater than the above estimation of the solid waste source. So in order to make plan to the city solid waste management, Sanitary and beautification bureau has used daily and annual household solid waste generation of 21,240kg per day and 2,930,400kg per annual respectively.

However, based on the above study the daily and annual generation of household of the city was much greater than the above estimation of the municipality. For making this survey 30 households were identified from three income levels purposively and after that the dust bin were given for each household and measured their solid waste for seven consecutive days and the findings of this survey were summarized in (Table 5).

Table 5:- Solid waste generation rate per the selected HHs.

Income groups	No. of sample households	Family size	Qt./HH/day(kg)	Qt./HH/week(kg)	Generation rate per individual(kg)
High income	10	33	16.98	118.86	0.514
Middle income	10	51	19.67	137.69	0.386
Low income	10	76	21.86	153.02	0.288
Total	30	160	58.51	409.57	0.367

Daily total solid waste generation of residential areas of the city was calculated as total population of the city (350,000) times per individual household solid waste generation rate. Based on the per individual household generation rate of 0.367kg, daily total solid waste generation of the city was 128,450kg. The annual total generation of solid waste was also 128,450kg times 365 days i.e. 46,884,250kg that was large and need immediate planning to achieve sustainable MSWM of the city. When 0.367 kg/d generation rate of Adama city is compared with other Ethiopian towns such as 0.277kg/day of Mekelle, 0.22 kg/day of Bahirdar, and 0.227kg/day of Debre markos shows that it was the highest of all generation rate developed by WHO cited in (Gebrie, 2009).

The amount of SW being generated from the city is too much to handle for the sanitary and beautification bureau. The household solid waste generation rate was increased by 0.143 kg/capita/day and which needs special attention for safe disposal, by all stake holders i.e. municipality, households, government and others (Table 6)

Table 6: Solid waste generation per randomly selected kebele

Kebele	kebeles' Population number	Solid waste generated averagely per day(kg)	Solid waste generated averagely per weak(Kg)	Solid waste generated averagely per month(kg)	Solid waste generated averagely per annum(kg)
Kebele 05	2436	894.01	6258.07	26820.3	326313.65
Kebele 08	2650	972.55	6807.85	29176.5	354980.75
Kebele 11	2800	1027.6	7193.2	30828	375074
Kebele 14	2340	858.78	6011.46	25763.4	313454.7
Total	10226	3752.94	26270.58	112588.2	1369823.1

Annual generation of solid waste of the four selected kebeles were 375074kg (kebele 11), 354980.75kg (kebele 08), 326313.65kg (kebele 05) and 313454.7kg (kebele 14). This shows that kebele 11 produces highest and kebele 14 produces least amount of solid waste among randomly selected four kebeles of Adama city.

4.3 Types of solid wastes mostly generated from the city

The largest percentage were plastic, which accounts 15.5%, the second large proportion was paper, which accounts 13.7% and thirdly bone holds 12.9%, so these solid waste materials were the largest proportion that were both legally and illegally disposed from each households. Therefore, according to the survey obtained it need great attention to be controlled and advised by household and municipality.

Table 7: Physical composition of solid wastes in Adama city

No.	Types of solid wastes	Weight in gram	Percentage
1.	Vegetable	99g	12.9
2.	Paper	105g	13.7
3.	Rubber	45g	5.8
4.	Plastics	120g	15.5
5.	Wood	55g	7.2
6.	Bone	96g	12.5
7.	Textiles	75g	9.7
8.	Metals	35g	4.5
9.	Glass	65g	8.5
10.	Leaves and left over chat	75g	9.7
11.	Total	768g	100

According to PAN (2008), SWM in developing countries tend to pay little attention to the issue of reducing organic wastes, while the quantity of solid wastes generated by society is increasing, the composition of waste is becoming more and more diversified with increasing use of packaging materials made of both paper and plastic.

The data obtained from the municipality and health office of the city using interview indicated that the major types of solid waste prevailed in the city were food waste, packaging, papers, wood, plastics, concrete, dirt and etc. The information obtained from the municipality and health offices, to identify the major types of solid wastes of the study area were not satisfactory to determine the extent of each types of solid wastes because in both offices there were no statistical documented sources regarding this issue. The key informants also mentioned used plastics by households and different business institutions as another dominant type of solid waste.

Generally, the awareness of most residents concerning the potential impact of poor management of solid wastes on their local environment and health was poor. As a result, they throw their wastes mainly food, plastic, left over chat and other waste in front of their home and on every corner of the city.

While the quantity of solid waste generated by society is increasing, the composition of waste is becoming more and more diversified with increasing use of packaging materials made by both paper, plastic and others (NUPI, 1989). Similar to the above stated literatures, the information obtained from the target population of this study agreed with the situation.

4.4 Secondary solid waste storage facilities and handling

Secondary storage facilities refers to different types of solid waste containers which involve keeping solid waste generated from different households at a common or central point from where collection vehicles can pick it and transport to final disposal site (Zebenay, 2010). Municipality provides these facilities, which is responsible for management of the city solid wastes. Adama city put 125 public solid waste containers in different areas of the city where frequent illegal dumping of waste was mostly occurred, and in areas where high population density was assumed to exist.

Residents around those containers were highly exposed and attacked by different solid waste caused diseases. This is mainly due to lifter truck being out of service, absence of frequent collection of those public solid waste containers, and miss use of the society. However, for solving problems of secondary storage facility, the city prepared different communal solid waste accumulation sites called transfer stations. Presently, transfer stations sites are not well designed and protected from rain and sun. They are just roadside, open dumps without any health and aesthetic impact considerations and optimum travel distance of beneficiaries. Therefore, those sites were created bad smell and ugly urban picture.

According to the interview with municipality head, those transfer stations give service only to MSEs Workers who collect solid wastes from households, institutions and commercial areas. He stated that in order to use transfer stations one should have to accumulate wastes by using sack and also he/she should load his/her accumulated waste by waiting municipality truck until it comes. Apart from transfer stations, there were also dustbins, which used to collect walkers' solid wastes like napkins, pieces of paper, and remains of fruits such as banana, orange, chat left over etc.

Around 125 dustbins were located at the major roads, recreational areas, market areas and institution. However, some of them are stolen and currently there were only few dustbins in the city.

4.5 Engagement of MSEs Employees in the solid waste collection activity

Most of the employees working on solid waste collection activity were engaged in the area because of no choice to do other work or poverty and unemployment. Therefore, it can be said that for most of the employees unemployment and poverty were the main driving factors to be involved in solid waste collection activity.

As indicated in most of solid waste collectors did not have interest to work on solid waste collection and disposal mechanism. About 54% of the respondents stated that the solid waste collectors work considering as temporarily job opportunity until they get another job opportunity.

Around 25% and 21% stated that, they were working even if the environment was not safe but due to poverty and no other job opportunity, they were engaged as MSEs Member to collect solid waste disposal from households (fig 6).

Therefore, it is possible to say that majority SW collectors were working until another job opportunity created and the other group was because of being poor or poverty were the driving factor to be engaged in solid waste collection. Still they did not interested working in solid waste collection activities because of poor safety, low awareness of the society, and low salary payment.

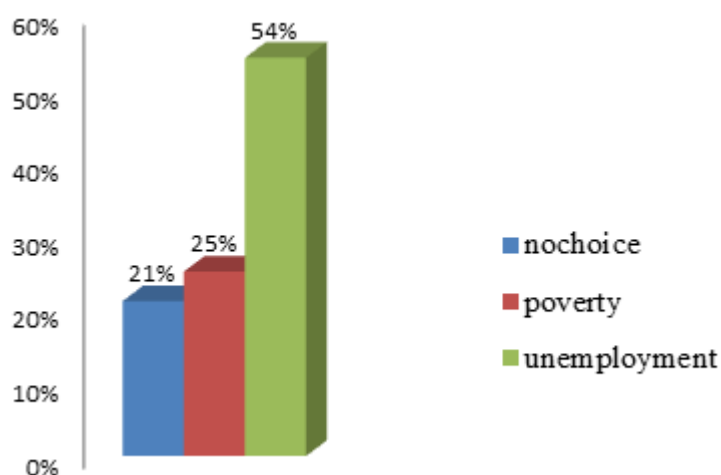


Figure 6: employ driving factor to work on solid waste collection activities

4.6 Collection system and working condition

Table 8:- Frequency of SW collection system in Adama city.

Frequency	No. of respondents	Percentage (%)
Twice a week	11	22.91%
Once a week	22	45.83%
Twice a month	9	18.75%
Once a month	4	8.3%
Zero frequency	2	4.16%
Total	48	100%

Out of the total number of respondents, 45.83% of the respondents reported that they collect household solid waste once in a week, 22.91% stated that they collect household solid waste twice in a week, 18.75% stated that they collect twice a month and about 12.5% stated that they collect household solid wastes once a month (Table 8). Thus, collection system and generation rate did not cope up with each other, because still even though the collection system is performed once per week, the solid waste disposed here and there needs more frequency to be collected.

4.7 Unsafe and safe SW disposal Activities

Table 9: Types of SW disposal methods in practice in Adama city

No.	Disposal methods	No. of respondents	Percentage (%)	Remarks
1	Public open spaces	92	47.92	Illegal
2	River or ditches	44	22.92	Illegal
3	Municipal carts	48	25	Legal
4	Burning	5	2.60	Illegal
5	Recycling	3	1.56	Legal
	Total	192	100	

It was observed that still open dumping of the waste was the prevailing activity practiced by residents of Adama city. It is clear that the majority of 47.92% population of Adama disposed waste illegally into public places, river or ditches 22.92%. Fewer households 2.77% reported that they practiced burning of the waste in some parts of the city to get unburden the collected waste. Such practice poses high risk on the local environment. Therefore, only 25% was well aware and legally dispose their wastes.

Improper solid waste management causes all types of pollution: - air, water and soil pollution. Indiscriminate dumping of wastes contaminates surface and ground water supplies (Hassan, 1998). In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and flood during raining season. Uncontrolled burning of waste contributes significantly to urban air pollution. Health and safety issues also arise from improper solid waste management.

The U.S. Public Health Service identified 22 human diseases linked with improper disposal of solid waste (Achankeng, 2003). Collected waste from remaining 25% of the respondents was transported to dumping site by municipality. Only one truck was available for transportation of waste and even that was being engaged in various other activities of municipality. If the only available truck was assigned only for waste disposal by the municipality rather than other added activities, there would probability to increase safety solid waste disposal activities in the city.

Municipality is responsible for the transportation of collected wastes to dumping site, which is a plain land instead of landfill site. The MSW is dumped on land, more or less in an uncontrolled

manner, as practiced in majority of cities in other developing countries (Zurbbrug, 1999 (b)). These dumping site are not fenced and nearby village children and stray animals, flies and vultures could be seen easily in and around the dumping site, producing an unaesthetic view.

the amount of unsafe solid waste disposal were very high in low socio-economic level, which was 69 percent, medium in medium socio-economic level (28%) and very low in high socio-economic levels (3%) respectively (Fig 7). Therefore, it is important to give awareness on safe disposal of solid wastes to all income levels of the society in special focus to low income level of the city.

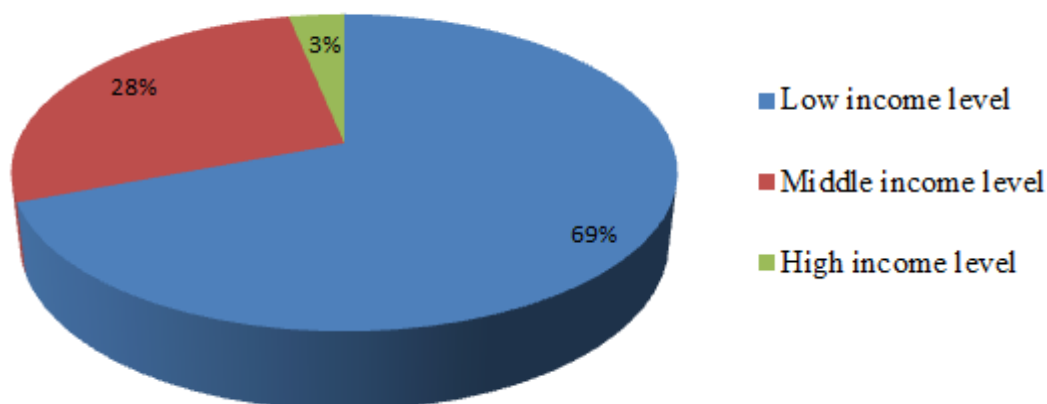


Figure 7: Unsafe disposal within socio-economic level of households

4.8 Transportation and storage of collected waste

Table 10: Types of transportation system

Transport system	No. of respondents	Percentages
Push cart	19	79.16%
Truck	5	20.83%
Total	24	100%

Majority of the employees in the study area collected wastes through door-to-door collection system and move it to the municipal transfer station point using MSEs own push carts. 79.16% used pushcart to transport solid wastes from households to storage or secondary storage area and 20.83%

use truck for the transportation (table 10). Still which is not satisfactory that means not sufficient to collect all the waste of the city.

Table 11: Types of secondary storage areas of solid wastes

Waste storage point	No. of respondent	Percentage
Municipal container	15	62.5%
Dispose it near full container	9	37.5%
Total	24	100%

About 62.5% of the employees stated that they used municipal container as a storage point of the collected waste until it is disposed to the final dumping site and 37.5% of the employees responded that they dispose it near full container until the truck comes (Table 11). This shows that there is a shortage of trucks to transport the collected waste from temporary dumping area (container) to the final dumping site, in the study area. Even it can stay for long period causing bad smell to society.

4.9 Types of working tools and equipment

In the questionnaire, the respondents were asked questions about their materials for collection of waste. The findings indicated that Pushcarts were the main working tools for primary collection from sources (households) to municipal transfer station.

Materials such as gloves, gown, shoe, mask, broom, refuse fork, digging shovels, drain drag and transportation and disposal vehicles. Therefore, the study indicates that, shortage of working tools particularly gloves, boots and transportation and disposal vehicles were the major constraint for the proper waste collection activity in the study area.

4.10 Accessibility of health and safety protection materials

Table 12: Health and hygiene protection materials

Items	No. of respondents	Percentage
Who did not use health and hygiene protection material	28	87.5
Who did use health and hygiene protection material	4	12.5
Total	32	100

About 87.5 % (Table 12) of the respondents did not use health and safety protection materials such as gown, gloves, mask and boots; only 12.5 percent of the employees were used health and hygiene protection materials. Therefore, it was clear from the results that the health condition of solid waste employees was at high risk since health protection materials were not fully provided to solid waste collectors. Health hazard was major threat of workers in solid waste collection activity.

4.11 Attitude of community (households) towards waste collectors

Table 13: Attitude of household towards waste collectors

Items	No. of respondents	Percentage
Encourages	34	71.8
Not recognized	8	16.6
Not responded	6	12.5
Total	48	100

In the questionnaire, the employees were asked questions about attitude of the community towards solid waste collectors. The findings indicate that about 71.8 percent of the employees had encouragement from the community to continue and expand their activity, and 16.6% of the employees were not recognized (Table 13). This shows that most of the community members in the study area recognize and were aware of solid waste collection activity as one part of job creation.

4.12 Household Roles

Table 14 :-The HHs response about the role of MSEs in collecting solid wastes.

No .	Items	Satisfac tory	Percent age	Mediu m	Percent age	low	Percen tage
1	Door-to-door Service by MSEs	12	30%	28	70%		
2	Amount of money paid to MSEs			16	40%	24	60%
3	How solid waste collected and prepared for MSEs to pick up	8	20%	14	35%	18	45%

Out of 40 respondents about 70% of them said that the door-to-door service provided by the MSEs is medium and the money paid for the solid collection was low where as about 60% of the household said the money paid per month is low. And they stated the reason as follow “ by now in the city the labor force payment ranged from 80-120 birr on per day and they are young if they participate in that job (construction) they can earn much more money than this one”. So, one can conclude from the households’ explanation that the payment was low and not motivating.

About 45% of the respondents said that their role in supporting the Micro was low and they explained the reason that the MSEs Came to respondents’ house in order to collect the dirty solid waste and clean gate or environment but the society attitude is low towards the safe solid waste disposal activities. Only about 35% said the assistance to them is medium. So one can conclude from the above table that the role of the households in supporting the MSEs during solid waste collection was low or the awareness creation to the household still needs great attention.

4.13 MSEs Officers’ role in supporting the micro and small scale enterprise

In the selected four kebeles, there were about six MSEs Officers and for the convenience of the research, we took all the kebele officers because according to the strategy the issue of micro is the concern of all leaders in the city. Generally, about 32 respondents took part in four kebeles as the table 15, shows below.

Table 15: The role of MSEs Officers of the kebeles in supporting the MSEs

n o.	Items	Measurement	percent age	Measurem ent	percenta ge	Measurement	Percen tage
1	What was the situation of waste collection before the enterprises intervention?	Good=0	0	poor=0	0	Bad =32	100%
2	What kind of assistance do you offer for solid waste collectors or	Material=6	18.75%	Training =26	81.25%	Others =0	0

	enterprises?						
3	What kind of challenges or problems, encountered the MSEs?	Public awareness=20	62.5%	Material =8	25%	Micro themselves are not confident in doing this job =4	12.5%

Officers in the four kebeles responded that before the intervention of the MSEs, the collection of waste disposal was bad i.e. out of the total respondents (MSEs Officers) all said (100%) bad collection system was prevailed in the kebeles.

About 81.25 percent of the micro members have got training on solid waste collection activity, only a few employees 18.75 percent did not get training. Thus, the result showed that most of the micro members are well trained about solid waste management service. This can be clearly shown, out of the 32 micro respondents about 81.25% (26) responded that their assistance was focused on giving training on the micro strategies, how they organize and save money.

The micro officers explained about the challenges faced as follow: - out of 32 micro respondents about 62.5% (20) said, public awareness is the basic problem, which faced the micro and it is demoralized them. Some of the challenges were collecting the solid waste properly and to make ready for the micro, some household were not volunteer to open their door for the micro that collects the solid waste and mixed solid waste with liquid waste. In addition, they explained the material problem, which faced the micro, for instance gloves that protected their health from solid waste contamination. Less number of the micro officers said the micro themselves are not confident about their job, assumed their job as temporary or without choice.

The Current SWM System households and other organizations have two options: - either disposing waste into a nearby container or having contract agreement with MSEs to dispose it into the container using hand pushed carts. Each MSE serves more than 1900 households and other organizations. Most households and low-income families prefer the first option i.e. disposing solid

wastes nearby container, as no cost was incurred on them. Some middle and high-income households prefer the second option i.e. having contract with MSEs to dispose solid wastes in to the container using hand pushcarts.

Besides, primary operation the municipality provides street sweeping services twice in a week for a total of 60kms. The mode of the service is provided by municipality sanitation workers and MSEs using facilities such as straw brooms, wheel barrow and shovel and street side public garbage bins for street users and pedestrians drop some waste stuff in to the public garbage bins when they are out of their homes and business offices. The low performance was due to the inadequate number of dustbins in the locality and the lack of public awareness to drop SW, especially paper, left over chat and plastic materials in the dustbins.

In the secondary operation, municipality with one-skip loaders carries out waste collection and transportation and vehicles from MSEs While in the third operation the transported waste is disposed by the municipality in an open dumping site 8Kms away from the city.

Majority of the interviewers witnessed the SWM system of the city did not go hand in hand with the development of the city and no effort has been made by the city administration to properly manage SW. All the interviewers reported that the current SWM system of the city is very poor because of lack of coordination among stakeholders, insufficient communal containers were available in Kebeles i.e. 05, 08, 11 and 14 and even those few containers were not picked when filled, Inadequate number of vehicles deployed, Unavailability of performance measurement system in the entire SWM chain. MSEs and private collectors did not serve the community properly and regularly. Besides, there was lack of control by the city administration. The society did not have any idea about the amount of waste generated in the city. In general, the services were not provided to the desired level. SWM has now been a problem not only to the city but also to rural areas causing impact on the environment and the inhabitants.

4.14 Constraints and problems of enterprises

The interviews in the study area generally confirmed that lack of working tools and finance were their major problems for the growth and development of the enterprises. Shortage of finance was the main problem of the enterprises in the study area. This is because the availability of capital

means the availability of working tools like pushcarts, disposal vehicles and other hygiene protection materials.

Problem of temporary storage area and containers for the collected waste were also another challenge in the study area and lack of awareness of households. Due to shortage of municipal containers and disposal vehicles, wastes were found scattered around areas of temporary dumping sites and transfer stations.

The employees believed that wastes have to be collected early in the morning from each households or business area. Nevertheless, during the process of door-to-door collection, some household do not swiftly give their waste to the collectors. This in turn affects the service coverage in that particular area. Hence, since much time is wasted in such a way, some households that should get the service did not serve according to their program. To give solid waste collection and disposal service to the users, containers should be emptied timely. If this is so, wastes that will be disposed out of containers will be reduced.

4.15 Factors affecting activities of solid waste employees in the area

4.15.1 Lack of recognition

Interview result showed that, the community does not give respect to them and their job. Therefore, social factors and awareness have a direct impact in constraining solid waste management system because the social status of waste management workers was generally low.

4.15.2 Equipment

Availability or unavailability of different pieces of equipment plays a significant role in waste collection activities. Some areas are very disadvantaged compared to others. In relation to placing of containers, since some of the containers are placed very close to residential houses, those residents living near containers frequently complain about the stinking smell, which, at times, causes health breakdown.

Based on the placement of the containers, it is possible to conclude that the distribution of containers were not based on population density and amount of domestic solid waste generation rather it centers on the presence of open space (EPA, 1996).

4.16 Household view towards solid waste collectors

According to the 45 interviews, the respondents stated that previously the majority of the households, which do not get the municipality service used to dispose of waste anywhere. Because of these, solid waste was seen here and there and it was difficult to go around this area due to the bad smell that came out of the waste. This day such a problem is seen at many areas of the city. One of the interviewers who reported about the performance of MSEs told that it was the MSEs that took the lion's share of waste collection service in the kebeles.

Nevertheless, lack of co-operation by community members has affected the solid waste management process. 34 out of 45 interviewees strongly agreed that the amount of money that the beneficiaries pay is less for the service that MSEs rendered. The respondents also stated that of all the urban services given by the municipality, waste management should be given priority because it is directly related to health. Therefore, they suggested that the government should improve the income of the solid waste collectors.

4.17 Solid waste collection & disposal operation

4.17.1 Primary Collection

This is very important to collect the solid wastes from households in efficient ways by the system called door-to-door or Street sweeping from the street. Thus, they are very important for the quality of SW collection as they are being primary activities.

4.17.2 Secondary Collection

Most of the respondents' educational level was high school and above high school. The average monthly income of respondents was also considered as an important variable that could influence people's perception and attitude about SWM system in the city as SW generation rates have direct relationship with income level.

Regarding the waste collection and disposal services, most of the respondents from the households as well as the respondents from organizations stated that MSEs gave the service sometimes. Regarding the frequency of disposal services, most of the time households reported they got the service once per a month and organizations once in two months.

5. Conclusions and Recommendations

5.1 Conclusions

Managing solid wastes in a safe manner is critical for sustainable development. Hence, municipalities and other stakeholders need to provide the SWM services properly. The study assessed the current SWM practices in Adama city and identified major challenges, which need to be addressed. The study is hoped to contribute towards establishing a sustainable environment and public health initiatives in the city. It gives insight to decision makers in developing a reliable SW generation rate, collection, separation, transportation, recycling and disposal systems which will lead to establishing a relatively risk free city. It can also serve as base line for further studies. Future work focuses on conceptualizing and developing SWM improvement model for the city.

The solid waste collectors that are organized in the form of MSEs can also generate employment and income for the poor. Most of the solid wastes were directly disposed in open spaces, ditches and roadsides due to poor accessibility to roads, rough surfaces and congested houses. These MSEs mainly play a role in primary collection, which is the collection of refuses from households to municipal transfer stations.

The involvement at MSEs in solid waste management services has tried to reduce the illegal disposal of wastes along the pass ways and to create the sense of community ownership to urban sanitation but which is at its early stage. With regard to the placement and distance of containers, many containers have not been located in proper open areas, some of them were placed close to residential areas, and almost no places where containers are found were fenced. It was observed that a heap of containers could be seen in few areas because of lack of open space and containers were not picked up timely. Whenever there is rain, the containers create stinking smell that pollutes the environment.

Low payment is one of the influential factors that affect the activities in waste collection activity i.e. since solid waste service providers are not paid equal pay for what they perform, this in turn decreases the moral of the employees. Therefore, the kebeles should consider all the factors that affect the service of solid waste collection activity and give immediate response to the problems. Inadequate salary and negative attitudes towards solid waste collectors are the main problem in the city.

5.2 Recommendations

Solid waste workers are highly exposed to health related problems. Therefore, the Micro officials are expected to provide health related educations either on job or prior to job training. This will reduce the health risk of employees because most of the employees are now working without hygienic protective materials. Motivated and moral building salary should be paid for solid waste collectors. The kebele should provide extra number of containers and placed available areas. Waste management can be best delivered only when the community takes active part in the service.

The attitude and respect of the society towards the solid waste collectors must be changed to positive and respectful. To this end, public awareness creation program is very important and needed. The current scenario of SWM in Adama city needs to be improved by integrating successful SWM strategies into all stages of the chain. Besides, the study forward the following measures for a sustainable SWM in the city, these are:

- Organizing continuous awareness campaign for all the stakeholders on how to manage SW properly.
- Re-establishing/improving the organizational structure of the WM with capable human lab our responsible for managing SW.
- Taking measures on those who illegally dispose wastes at any open spaces such as ditches. In fact, the ditches in the city should be covered.
- To have a sustainable SWM system, the city administration should follow participatory approach in the entire SWM activities. Hence, initiating and facilitating collaboration with all stakeholders are mandatory
- Appropriate facilities such as transporting vehicles, dustbins, other tools, and safety clothing must be provided as per the requirement of the waste to be disposed.
- Enough number of communal containers should be in place and SW needs to collect at optimum frequency so that waste should not be accumulated, overflowed or thrown in open spaces.
- There should be a well-organized performance measurement system so that it could be possible to know how the SWM operation is being operated and how to improve it. If these

measures are considered, the city administration can tackle the current SWM challenges and be able to deliver better services.

- Besides, in order to improve the SWM of the city for sustainable public health and environment and to realize the benefit of this effort, there is a need to conceptualize a SWM improvement scenario. In view of this, the four improvement initiatives for considerations, i.e. institutional capability, collaboration with stakeholders, availability of funding and facilities and efficient SWM system setup.



Figure 1: Koshe or Raphe solid waste disposal (Addis Ababa, Ethiopia)

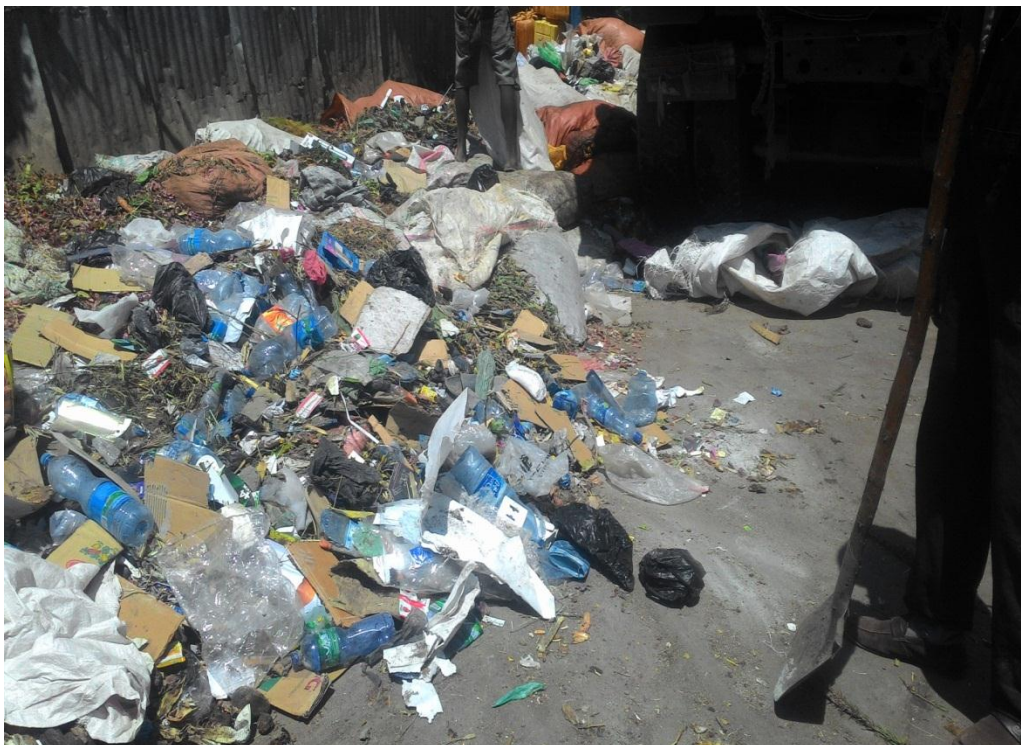


Figure 2: The solid waste illegally disposed around Gimb (kebele 05).



Figure 3: Solid waste illegally disposed around kebele 08, which is causing unpleasant odor.



Figure 4: Unsafely disposed solid waste filled the canal around kebele 11.



Figure 5: Solid wastes illegally disposed, which is causing bad smell around old bus station.



Figure 6: SW collected and left near to the old railway for long time by MSEs in kebele 14.



Figure 7: Solid waste over flowing the container around Abyssinia bank of Kebele 05



Figure 8: Push carts used by solid waste collectors in kebeles 14 (transfer station).

6. REFERENCES

- Aboho, S.Y., Oketunde, F.O., Eneji, I.S, (2006), survey of solid waste generation and Composition, a rapidly growing urban area in central Nigeria waste management.
- Abebe Tegegn (2006). The Involvement of Micro and Small Enterprises in Solid Waste Management Services in Addis Ababa: The Case of Bole and Arada Sub-cities, Ethiopia.
- Achankeng E. (2003). Globalization, urbanization and municipal solid waste management in Africa: African studies association of Australia and the pacific. Conference Proceeding-Africa on a global stage pp.15
- Addis Anteneh, (2004). Adama city profile and action plan Vol.1 urban poverty Participatory Action research institute (ARI).
- Bartone, c. (1996). Urban environmental priorities. World Bank environment department , Washington D.C.
- Bernstein, (2004). Urban municipal solid waste management, PP.36
- Creswell, (2003). Urban solid waste management in developing Countries, PP., 21-23
- Dolk, M., (1997). Residents near waste. Landfill sites and risk of non-chromo Sal congenital Malformations, collaboration study group, New York.
- Enyew Ali (2013). Assessment of the challenges and prospects of micro and Small Enterprise Operating on solid waste collection Activity: The case of Arada sub city: Addis Ababa: Ethiopia.
- EPA (1996).Tool Kit for Solid Waste Management. Intermountain Region-National Park Service
- EPHTI (2004). Solid Waste Management. For Environment and Occupational Health Students. In collaboration with the Carter Center, the Ethiopian Minister of Health, And the Ethiopian Ministry of Education. Takele Tadesse, Gondar University.
- Fanta, Z.C, (2006). Urban solid waste management in developing country.
- Federal democratic republic of Ethiopia proclamation number 513/2007, (2007).Solid waste Management.
- Freiburg (2015). An efficient and effective e-waste collection system for Ethiopia; Final Report

- Hassen Mussa, (1998). Addis Ababa City Environmental health service problems And solutions. A project designed to tackle problems of the city. Addis Ababa.
- Hasan S. (2004). Public awareness is key to successful waste management. Center for Applied Environmental Research, Department of Geosciences, University of Missouri, Kansas City, USA.
- Juhasz.A.L (2004).Waste management: Center for environmental risk Assessment and remediation , University of South Australia, Maw son Lakes.SA, Australia, pp. 35-50, and 121-154.
- Marshal, E. (1995). Analytic study to evaluate associations between dumpsites and birth Effects. Atlanta, pp. 42.
- Medina, M. (2002). Globalization, development and municipal solid water management in Third world Cities. PP., 31.
- Michael, W., (1995). An Integrated course for Geography, Stanley Thrones Ltd, England
- Ministry of environment (2010). Republic of Korea annual report of volume based waste fee. Shanghai manual guide for sustainable urban development in the 21st century.
- Mohammed Aljaradin and Kenneth Mm., person, (2012). Environmental Impact of Municipal Solid waste Landfills in Semi-Arid climate. Case study, Jordan. Department of Water Resource Engineering, Lund University. Lund, Sweden.
- Mustafa, N., (1993). Plastics water management, disposal, recycling, and refuse. London. Marcel. Ghana, Legon.
- NATIONAL URBAN PLANNING INSTITUTE, Sir William Hal crow, Tahal consulting Engineers Ltd., Building Enterprise, and Hagos Tsehay Consultant, (1989). Integrated Urban Rural Development of Market towns development Addis Ababa, Akaki, Assela, Ambo, Arsi Negele, Robe, Mizan Teferi, Goba, Wolisso, Ziway, Shashemene.
- PAN, (2008). Best practices on solid water Management of Nepalese cities. Supported by European Union under the EC Asia pro. ECO-programmer practical Action Nepal. Kathmandu, Nepal.
- Sandra, C.L. (1995). Urban Management programs. Urban Management and the Environment. Private sector participation in Municipal solid waste Services in Developing countries.
- Smith, (2010). *What is Solid Waste Management?* Retrieved from(<http://www.wise.greek.com/>)

- what-is-solid-waste-managment.htm) web page accessed, august15)
- Takele Tadesse, (2004) .Solid and hazardous waste management: Ethiopian public health Training initiative: Gondar University.
- Tefera Damtew, Y.and Negussie Desta (2015). Micro and Small Enterprises in solid waste Management: experience of selected Cities and Towns in Ethiopia
- Techobanoglous. G., Theinsen H., and Samuel A. (1993).Integrated solid waste Management engineering principles and management issues.
- UN-Habitat, (2010) urbanization facts and figures, Nairobi, Kenya
- UNIDO, (2001).United Nation Environmental Program Division of Industry, Technology Economics, U.N code of federal regulation, part 243, (1995).
- Wentz AC (1989). Hazardous Waste Management: Chemical Engineering series. Argonne National laboratory
- WHO, (1996). Cholera-1994, situation in the African region, WHO, Harare, Zimbabwe.
- Wilson, (2006). Role of informal sector recycling in waste Management in developing countries. Habitat International 30.
- World Bank, (2006) strategic planning guide for municipal solid waste management
- Yohannis Birhanu, Assessment of solid waste management practices and The role of public participation:The case Jigjig Town, Somali Regional state ,Ethiopia:(2015) pp., 153- 168
- Zebeay Kassa (2010). The Challenges of Solid Waste Management in Urban Areas, the Case of Debre markos Town, Ethiopia
- Zurbruggs C, (1999).Urban solid waste management in low-income countries of How to cope with garbage crises, Dueberdorf, Swizerland

APPENDIX I

A Questionnaire Prepared for Sample households in Adama city, for selected kebeles in focus. The questionnaire is prepared for an academic purpose for the fulfillment of MSc. Degree in Biology. The objective of the study is to assess the challenges of waste generation rate and disposal mechanism of solid wastes in Adama city. Thus to identify solutions, your response is very important for the success of the study. Your name will not be mentioned to others. We would like to thank you for your cooperation.

I. Respondent's background

A. Sex Male Female

☐	☐
--------------------------	--------------------------

B. Religion Christian Muslim protestant others

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

C. Educational status:

Basic education	☐
Elementary school	☐
High school	☐
Higher education	☐

1. What do you think is the major source of solid wastes found in your area?

The major type of waste you mentioned under question No. 1. Primarily

Generates from which source of solid wastes?

- A. agricultural sources
- B. commercial and institutional sources
- C. construction and demolition sources
- D. residential sources

2. Do you have temporary solid waste storage in your home?
Yes-----, NO-----, if yes what kind? -----
3. Do you reuse household wastes? Yes-----, no-----
If yes what kind? -----
4. Did you sell household wastes? Yes-----, no-----
If yes what types? -----
5. Do you burn solid wastes? Yes-----, no-----
If yes, have you arranged a place for waste burning?
Yes-----
No-----
6. Where the enterprises dump the collected waste?
A. At municipal transfer points B. At the municipal truck
C. At final dump site of the municipality D. Specify/any _____
7. Where does the enterprise store the collected waste if municipal containers are full
Or not emptied timely?
A. Will watch until the municipal truck comes
B. Dispose it near to full containers
C. Store it with own temporary handling
D. Burn it
8. Is there any enterprise established for collection of wastes in the city?
Yes-----, no-----

ANSWER QUESTION 10-13 IF YOUR ANSWER FOR QUESTION NO.8 IS YES

10. How many workers had the enterprise when it started solid
Waste collection activity?
A. Female _____
B. Male _____
c. Total _____
11. When do you engaged in this enterprise? Since _____Ethiopian
Calendar.
A. about 1 year B. from 1- 2 years
C. from 3-4 years D. from 5- 6 years

- e. above 6 years
12. What do you think that initiated the enterprise to involve in this activity?
- a. Untapped opportunity of the sector b. For survival
 - c. Family business background d. Specify if any _____
13. How often does the enterprise collect solid waste from household Clients?
- A. Daily B. Twice- in a month
 - C. Twice in week D. Once in a month
 - E. Once in a week f. Others/ specify _____
14. What actions do they take on persons who improperly dispose wastes?

15. Which method of solid waste disposal system is commonly practiced by your Family to dispose the solid wastes generated from your house/home.
- a. Sanitary land fill/SLF/
 - b. Composting
 - c. Open burning
 - d. Open dumping
 - e. Other/specify
16. If your answer to question number 15 is choice B, C, D or E do you think These sites are properly selected and sited? If yes, explain their properness
If not explain the impacts.
17. Suggest alternative disposal system need, to be practiced by the Community of your town and by your municipality to replace Environmentally hazardous methods of disposal. ----- And state the Advantage of the suggested disposal system on your environment;
18. is there accessibility road to the nearest container?
- Yes-----
- No-----
19. What means do you use to transport wastes?
- A. by hands (ourselves) -----
 - B. hand pushed carts (kurkur) -----

- C. horse drawn carts-----
- D. if, others specify-----
20. Is there anybody who monitors that waste is properly collected and transported to the disposal site?
- Yes-----, no-----
- If yes, who? -----
21. What transportation systems the enterprise used to transport the garbage from its Source to transfer points?
- A. Own vehicles B. Own carts C. Rented pushcarts
- D. Rented vehicles E. Specify/any _____
- F. Specify/any _____
22. Are the following materials and equipment used for the collection of solid Wastes are available in your city?
- A. Collection container I. yes II. No
- B. Collection truck I. Yes II. No
- C. Collection crew I. Yes II. No
23. If your answer to question number 22, choice A, is yes, are they sited at Proper place ? Are they given necessary services? Explain;
-
24. What is the attitude of the community towards the enterprise working on solid Waste collection?
- A. Encouragement
- B. exclusion from any social affairs
- C. Giving advice to stop the work
- C. Specify if any _____
25. What possible solution measures do you think the waste management System of your city needs to be socially acceptable, economically affordable and environmentally effective? -----
26. Which waste is the major type of solid waste you found in your area?
- A. paper waste
- B. food waste and their packaging

- C. construction and demolition wastes
 - D. plastics
 - E. other type/specify
27. Is there any labor in charged with daily removal of solid waste in your Surrounding /kebele? A. Yes B. No
28. If your answer to question number 27 is yes, do you think there are enough Labors in your city? Are they effectively working? Explain.
29. If your answer to question number 26 is no, what do you think are its Negative impacts on SWM activities of your town?
30. Do you think that the solid waste disposal system your family is practicing In particular and the SWM system of your town in general are safe, effective, Efficient and environmentally friendly? A if yes how? B. If No, Specify the major factors behind;
31. Which one of the following environmental impact do you think is the major result of poor solid waste management system of the city?
- a. Water pollution problem
 - b. Land management and conservation problem
 - c. Loss of amenity
 - d. Air pollution
 - e. Other/specify

APPENDIX II

Interview with kebele administrator, city municipality and health officer:

1. What is the attitude of the community to wards safe disposal of wastes?
2. Do you think that there, is sufficient waste disposal service in the locality
Where you render service?
3. Do you see a timely disposal of waste containers?
4. Do you think that the waste containers are properly placed there by taking care
Of health and beauty factors of the community?
5. Do you believe that the community has a positive practice and attitude towards
Using waste containers?
6. What is your comment on ways of improving safe waste disposal services?
7. What can be done to improve the waste collection services (efficiency and
Effectiveness)?
8. What are the major types of solid wastes dominantly found in Adama city?
Explain in accordance of their dominance.
9. What are the major sources of solid wastes contributing to the major
Types of solid wastes found in Adama city? Explain in terms of their
Dominance contribution?
10. Do you think the solid waste disposal sites used for disposal of solid
Wastes generated from different sources are properly selected?

APPENDIX III

Gaafiwaan armaan gadittii qophaan kunin kaayoo dhimaa mastersiitif mataa duree ‘’ safissaa umaama xurii goggaa fi akkataa gatinsaa isaa Kan Magalaa Adama ‘’irratii qopha’ee jiraa.kaana waan ta’eef gaffilee dhiyataniratii seeraan akka irrati nuf hirmataan isiin gaafataa waan irratti hirmataanif galatoomaa jena.

Haalaa nammotaa yaadaa akka keenanif filaatamanii

Salaa dhi. ----- Du. -----

Amaantaa kiristaanaa musilimaa protestantii kan birraa

Haalaa sadarkaa barnootaa

Barnootaa iddlee elementary sadarkaa 2ffaa kollejjii ykn uniiversitii

2. Xuuriin goggaa naannoo ketittii yeroo baayee essaraa dhufaa dhufaa ?

a.qonnarra b.naannoo daldaalaa irraa c.konstrakishiin irra d.mana jirenyaa irraa

3. monaa manaa keetii bakkii yeroodhaaf xuuriin googaan itti kufaamuu jiraa?

a. jiraa b. hin jiruu c. yoo jiraa ta’ee haalaa kaamin -----

4. xuurii googaa mana keesa bahuu irraa debitaanii itti faayadamtuu ?

a. eeyeen b. mitii c. yoo eeyeen ta’ee isaa kaamii ?-----

5. xurii googaa kanaa gubduu ?

a. eeyeen b.mittii c. eeyeen yoo ta’ee bakki isaaf qopha’ee jiraa ?-----

6. warii xurii googaa mana manatii guraan essatii gatu?

a. bakkaa akka magalaaatti yeroodhaaf kufaamuttii

b. bakkaa kontineerii ittii ka’aamee

c. bollaa kessatii

d. bakkaa addaa yoo ta’ee haa ibsaamuu.

7. xurii googaa IMX dhaan walittii qabamee yoo kontineerii guttee essaattii kufaamaa

A. hamaa tirakiin kaasuu dhufuttii caalisaan laaluu

B. kontineeraa guttee biraattii kusuu

C. bakkaa dhunfaa isaanittii keewatuu

D. nii gubamaa

8. IMX aan xuurii googaa guruudhaaf ijaaramee magalaa keessaa jiraa ?

A. eyeen B. mittii

9. IMX aan yeroo jalqabaatii miseensaa hojetootea meqaa qaabaa?

A. dhiraa -----

B. dubraa-----

C. waalittii qabaa-----

10. Maalif jeetaan yaaduu interpraasiin kun kan xurii googaa kanaa guruuf kaan kaakasee?

A. hiyumaa B. hojii dhabdumaa C. yeroo ittin dabarfachuuf D. kan biraa yoo jiratee haa ibsaamuu-----

11. IMX aan torbaanittii yeroo meeqaa xuurii gogaa kanaa mana nama tokkoo kessaa sassaabaa?

A. yeroo lama B. yeroo afurii C. yeroo tokko D. akkummaa nuu mijaateetii

12. Taarkanfii maaltuu fudhataama namaa xuuriigogaa baakaa hin eyaamamnetii gatuuraatii?

13. Xuurii googaa manaa keesanii bahuu essatii gaatamaa?

A. bakkaa contiineerii ka'meettii B. bakkaa xuriin baay'een ittii gatamuutii C. ni gubaamaa

D. rasaa barbaadneetii ittii gaanaa E. bakkaa xuriin gogaan magaala ittii gatamuutii

14. Xuurii gogaa meshaa maalittin gegeefamaa garaa kontineeratii?

A. haarkaan B. kurikuridhaan C. Gaarii faardaatiin D. Kaanbiraa yoo jiraatee ibsaa

15. Haalaa kaamiin xurii gogaa bakkaa xuriin magaalaa ittii gataamutii gefaamaa ?

A. maakinaadhaan B. kontineeraan C. kaanbiraa yoo jiraatee haa ibsaamuu -----

16. Kaaraan manaa kessaniraa bakkaa kontineeraa geesuu jiraa?

A. eyeen B. hin jiruu

17. Yaadnii umataa namootaa xurii gogaa manaa manattii sassabaniratti maalii fakataa?

A. ni jajabeessu B. moraalii keenuufii C. hin jajabessaan D. akkaa hojatoatatii hin ilaalan

E. kan biraa yoo jiratee ibsii -----

18. xuriin googaan kun akkaamitii yoo gataamee halaa qulqulaa ta'een , halaa nannoo hin baaleesinniini ta'uu danda'aa?

A. madaa isaa hir'isudhaan B. gubuudhaan C. irraa dedebi'aan fayaadamudhaan D. bakkaa
laandiifilii jedhaamutii gatudhaan E. haalii addaa yoo jiraatee haa ibsaamu -----

19. isaan armaan gadii kanaa keessa isaa kamtuu baay'inaan xuurii gogaadhaan saxilaamaa magalaa
keesatii?

A. xuraawuu bishaanii B. xuraawuu qileensaa C. xuraawuu biyee D. kan biro -----

20. quulqulinni namootaa xurii gogaa sasaabanii hamamii egamaadhaa jetanii yaaduu?

A. baay'ee garii dhaa B. hin egaamuuf C. rakinaa guddaa irraa jiruu D. gidduugalessaa

APPENDIX IV

ማስተርስ ዲግሪ በከፊሊ ለሚሟላት ጥናትና ምርምር “በደረቅ ቆሻሻ አፈጣጠርና አወጋገድ ስርአት በአዳማ ከተማ” በሚለው ላይ ለመስራት ነው። ነገር ግን ይህንን ለማድረግ የሚከተሉትን ጥያቄዎች በመመለስ እንድትተባበሩን በትህትና እጠይቃለሁ። ለምታደርጉልን ትብብር እናመሰግናለን።

1. ሃሳብን የሚሰጡ ሰዎች ታሪክ

ጾታ

ወንድ

☐

ሴት

☐

ሐይማኖት

ክርስቲያን

☐

ሙስሊም

☐

ፕሮቴስታንት

☐

ሌላ

☐

የትምህርት ደረጃ

መሰረተ ት/ት

☐

1ኛ ዙር

☐

2ኛ ዙር

☐

ከፍተኛ ተቋም

☐

2. ደረቅ ቆሻሻ እናንተ አካባቢ ከየት ይመጣል ብለሽ ነው የምታስቢው/የምታስበው?

ሀ. ከእርሻ

ለ. ከንግድ አካባቢ

ሐ. ከኮንስትራክሽን

መ. ከመኖሪያ ቤት

3. ከእናንተ ግቢ ውስጥ ደረቅ ቆሻሻ በጊዜያዊነት የሚጠራቀምበት ቦታ አለ ወይ?

ሀ. አለ

ለ. የለም

ሐ. ካለ በምን መልኩ ነው የሚከማቸው

4. ከመኖሪያ ቤት የሚወጣው ደረቅ ቆሻሻ መልሳችሁ ትጠቀማላችሁ ወይ

ሀ. አዎ

ለ. አይደለም

ሐ. አዎ ከሆነ ምን አይነቱን

5. ደረቅ ቆሻሻ ይቃጠላል ወይ?

ሀ. አዎ

ለ. አይደለም

ሐ. አዎ ከሆነ ለዚህ የተዘጋጀ ቦታ አለ ወይ

6. ደረቅ ቆሻሻ ቤት ለቤት እየዞሩ የሚሰበሰቡ ማይክሮ የት ነው የሚጥሉት?

ሀ. ላንድ ፊል በሚባልበት ቦታ

ለ. ኮንቲነር የተቀመጠበት ቦታ

ሐ. ሜዳ ላይ

መ. ሌላ ካለ ይግለጹ

7. በማይክሮ የተሰበሰበውን ኮንቴነሩ ከሞላ የት ነው የሚሰበሰበው?

ሀ. የሚያርስ መኪና እስኪመጣ ይጠበቃል

ለ. የሞላ ኮንቴነር አጠገብ ይደፋል

ሐ. ባዶ ቦታ ተፈልጎ ይደፋል

መ. ሌላ ካለ ይግለጹ

8. በማይክሮ ተደራጅተው ደረቅ ቆሻሻ የሚሰበሰቡ አሉ ወይ?

ሀ. አዎ

ለ. አይደለም

9. ለጥያቄ ስምንት አዎ ከሆነ ስንት አባላት አላቸው?

ሀ. ወንድ

ለ. ሴት

ሐ. አጠቃላይ

10. ምን አነሳስቶህ ነው እነዚህ ማክሮ ደረቅ ቆሻሻ የሚሰበሰቡት?

ሀ. ከድህነት

ለ. ከስራ አጥነት

ሐ. ሌላ ስራ እስኪገኝ ተብሎ

መ. ሌላ

11. ይህ ማይክሮ በሳምንት ስንት ጊዜ ከአንድ ግለሰብ ቤት ደረቅ ቆሻሻ የሚሰበሰቡት?
- ሀ. ሁለት ጊዜ ለ. ሦስት ጊዜ ሐ. አንድ ጊዜ መ. እንደተመቻቸው
12. ምን አይነት እርምጃ ነው የሚወሰደው አንድ ሰው ባልተፈቀደበት ቦታ ደረቅ ቆሻሻ የሚጥል ከሆነ?
- ሀ. ምንም አይነት ለ. ይመከራል ሐ. አይተው ዝም ይላል መ. ሌላ
13. በብዛት ከቤት የሚወጣ ደረቅ ቆሻሻ የት ነው እንደ ከተማው የሚጣለው?
- ሀ. ኮንቴነር የተቀመጠበት ቦታ ለ. እንደ ከተማ ቆሻሻ የሚጣልበት ቦታ
- ሐ. እንደተመቻቸው መ. ይቃጠላል ሠ. ሜዳ ላይ ነው
14. ደረቅ ቆሻሻን ከቤት ወደ ኮንቴነሩ በምን ይጓዛል?
- ሀ. በእጅ ለ. በኩሩኩር ሐ. በፈረስ ጋሪ መ. በማይክሮ ኩሩኩር ሠ. ሌላ
15. በምን ፍጥነት ነው የከተማው አስተዳደር ደረቅ ቆሻሻ ከኮንቴነር ወደ ላንድ ፊል የሚያጋጥመው?
- ሀ. በወር አንዴ ለ. በወር ሁለት ጊዜ ሐ. እንደተመቻቸው መ. ሌላ __
16. ደረቅ ቆሻሻ ለመጣልም ሆነ እንዲሰበሰብ የተለየ መንገድ አለ ወይ?
- ሀ. አዎ ለ. የለም ሐ. አዎ ከሆነ እንዴት _____
17. ከህብረተሰቡ አስተሳሰብ ደረቅ ቆሻሻ በሚሰበሰቡት ላይ ምን ይመስላል?
- ሀ. ያበረታታሉ ለ. ሞራል ይሰጣሉ ሐ. ክብር አይሰጣቸውም
- መ. እንደሰራተኛ አይታዩም ሠ. ሌላ
18. ይህ ደረቅ ቆሻሻ እንደ ከተማውም በምን መልኩ ቢሰበሰብ ለአካባቢውም ሆነ ለጤንነት ጥንቃቄ የሚኖረው?
- ሀ. ምንጩን በመቀነስ ለ. በማቃጠል
- ሐ. መልሰው ለተለያዩ ጥቅም በማዋል መ. ሌላ
19. ከዚህ በታች ከተዘረዘሩት ውስጥ በብዛት የትኛው ነው ለደረቅ ቆሻሻ የሚያጋልጠው በተለይ በከተማ ውስጥ?
- ሀ. የመጠጥ ውሃ በመብከል ለ. የአየር ንብረት በመብከል
- ሐ. የአፈር ብክለት መ. ሌላ
20. ደረቅ ቆሻሻ የሚሰበሰቡት ማይክሮዎች ጤንነታቸውን ምን ያህል መከላከያ መሳሪያ ይጠቀማሉ?
- ሀ. በጥሩ ሁኔታ የተጠበቀ ነው ለ. አይጠብቁም
- ሐ. ትልቅ ችግር ላይ ናቸው መ. ሁሉም