

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

***Domestic Solid Waste Management in Mekelle
City: Tigray Region***

By

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June, 2002

***DOMESTIC SOLID WASTE MANAGEMENT IN
MEKELLE CITY: TIGRAY REGION***

**A Thesis Submitted to the School of Graduate
Studies of Addis Ababa University**

***In Partial Fulfillment of the Requirements for the Degree of
the Master of Arts in Human Geography***

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***DEPARTMENT OF GEOGRAPHY
SCHOOL OF GRADUATES STUDIES***

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DECLARATION

The thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

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Domestic Solid Waste Management in Mekelle City: Tigray Region

By G/Tsadkan G/Michael

ABSTRACT

This study examines the overall pattern of solid waste generation, collection and disposed in Mekelle city by analyzing primary as well as secondary data. The findings show that about 39792.9Kg of solid waste in a day and 1424408.5kg in a year were generated in Mekelle in 2001. The largest proportion, over 75%, of the solid waste was of residential origin, i.e. domestic solid waste, which predominantly consists organic items such as ash and garbage. In general the amount of solid waste generated was found to be a function of household income, where the lower, the middle and the higher income groups generate 0.277 kg,, 0.301 kg and 0.412 kg per capita per day respectively.

In the year 2001 the solid waste collection and disposal service coverage by the Health Office of Mekelle was only 39.38%. The main factors behind the poor performance include improper organizational structure, shortage and dissatisfaction of the workers, inadequacy and inappropriateness of the collection and transportation facilities (both the containers and vehicles), unfair distribution and sitting (placement) of the containers, and inadequate financial resources. Moreover, there were no detailed rules and regulations, ordinance and public education concerning solid waste management. The site selected for solid waste disposal, the disposal technique and the solid waste collecting and transporting techniques used were also part of the main constraints of the solid waste management in the city of Mekelle.

The findings also indicate that certain social-cultural factors have aggravated the problem of solid waste management in Mekelle. The leading factors in this regard include improper handling of solid wastes at home, improper transfer of solid waste into the container and the illegal disposal of solid waste anywhere in the city.

The findings of the survey, in general, suggest that the Mekelle City Administration, particularly its Health Office, take the necessary measures in order to improve the City's solid waste management service. Moreover, the Health Office has to make efforts to achieve a meaningful level of community participation in its endeavors to create a clean and healthy urban environment.

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CHAPTER ONE

INTRODUCTION

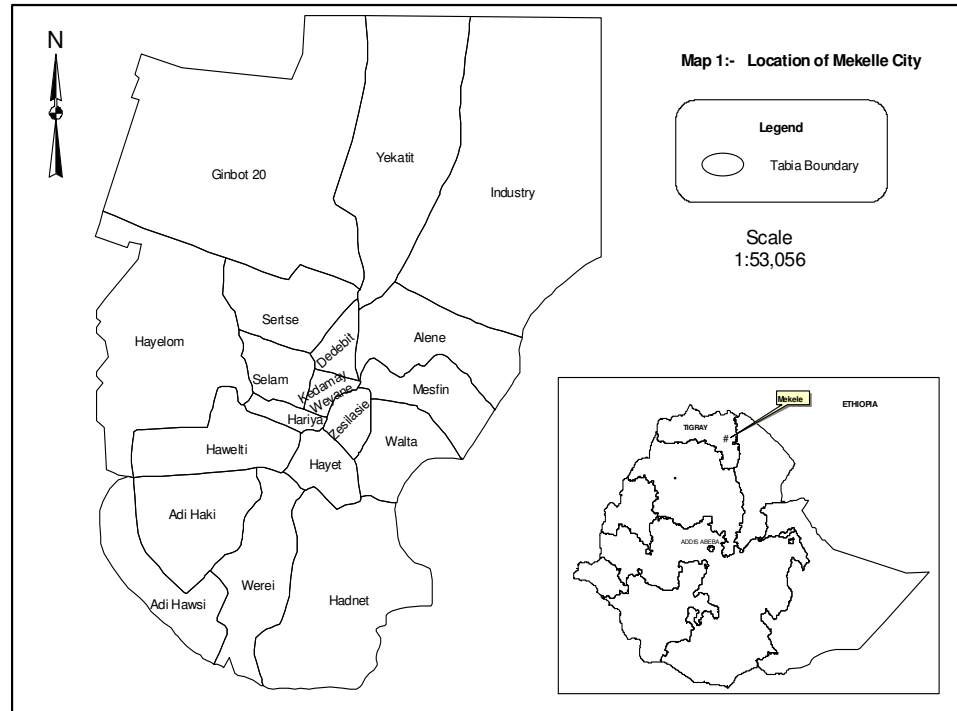
1.1 Background of the Study Area

1.1.1 Physical Background

Mekelle is one of the most important cities of Ethiopia found in the Northern part, in the Tigray National Regional State. Astronomically, Mekelle is located at $13^{\circ} 32'$ N latitude and $39^{\circ} 33'$ E longitudes. It is about 780 km north of Addis Ababa.

The city is situated at almost west and southwest bottom of the fault and tilted inter-bedded shale and limestone beds that extends East-West from the Endayeus to Messebo uplands. The slope of the city generally a decrease towards west of it where its future expansion may largely depends upon. The average elevation of Mekelle is 2200-meter a.s.l. and have a Woinadega type of climate. The mean maximum temperature of the city is 24.4°C where the highest monthly mean temperature occurs in June (27.2°C). The mean minimum temperature is 10.7°C where December (7.5°C) has the lowest monthly average minimum temperature. The mean annual temperature of the city is 17.6°C that ranges between 15.0°C (December) and 20°C (June) (NUPI, 1993).

The rainfall characterizes of the city is bio-modal type where the minimum rainfall and maximum rainfall occur in autumn and summer (Keremt) respectively. The mean annual rainfall is 579 mm where the highest occurs in August (222.7 mm) and the lowest in December (0.8mm)



1.1.2 Socio-Economic Background

Historical Overview

It is believed that Emperor Yohannis IV founded Mekelle as a capital of Ethiopian Emperor about 110 years ago. In 1872 Italian Engineers started the building of the Emperor's palace. After a year the building of the palace was completed and the Emperor shifted his capital from Adwa to Mekelle. Later when Emperor Yohannis IV died, the capital of the Empire moved to Addis Ababa and since then Mekelle has remained the capital of the Tigray Region (or kiflehager).

As certain references and studies have indicated Mekelle, since it has been established as a capital, has involved an important growth in Population as well as in Socio-economy. The socio-economic growth occurred during the Italian occupation was particularly considerable. The construction of road networks that connected Mekelle with the nearby villages and with the main cities of Tigray like Abi Adi, Sokota, and Adwa was accomplished during the five years Italian occupation.

It is also indicated that airports (that necessarily was airstrip or airfield), hospitals, school named “Scoula Indigena” (Exclusively for Ethiopians) was constructed during the Italian occupation. Moreover, in the field of trade, a significant change had taken place. Shops, hotels, groceries and cinema halls were widely flourished in the city. The construction of many buildings for various purposes (including for administrative purposes) had been undertaken.

Administratively, Mekelle, the capital of the National Regional State of Tigray, has recently stood as a special zone on its own right. The Special Zone of Mekelle has been divided into two administrative Woredas (Northern and Southern Woreda) and further subdivided into 19 Tabias. Note, Tibia refers to the smallest administration unit (usually

equivalent to Kebele) while woreda is the second largest administration unit next to Tabia. In fact it is know in process to incorporate the nearby two towns-Quiha and Aynalem, with Mekellel Special Zone.

One of the very dynamic phenomena of Mekelle is the population growth. The rate of urbanization of the city is very high which is typical to the developing countries urban area.

In 2001 there was about 34906 households (Health Office, Polio-Eradication Campaign). Based on the average family size of household of urban areas of Tigray, as indicated in the 1994 population and housing census (3.8), total population of Mekelle in 2001 has been estimated as 132643. This means that the population has increased on the average by 4.62% annually since 1994(See Table 1).

Table 1 Population Number, by year and source, Mekelle City

Year	1984	1994	1999	2001	1984-94	1994-2001
Source	CSA	CSA	BPED	H.O		
Population	61,583	96,938	105,060	132643	4.64	4.62

BPED = Bureau of Planning of Economic Development

H.O= Health Office

The population distribution of the city by Tabia of the 2001 indicated that there was a wide variation among the Tabia. Tabia Adi Haki had highest number of residents that accounts for about 9.9 % of the city's population where as Tabia Hayet has the lowest number of residents, that is only about 2.2 % (see table 2).

The educational background shows that currently there are five higher institutions such as 1 university and 4 colleges (2 private and 2 government) and 3 training centers in the city. On the other hand, in 1994 there are 18 primary schools and 6 secondary schools. In the same

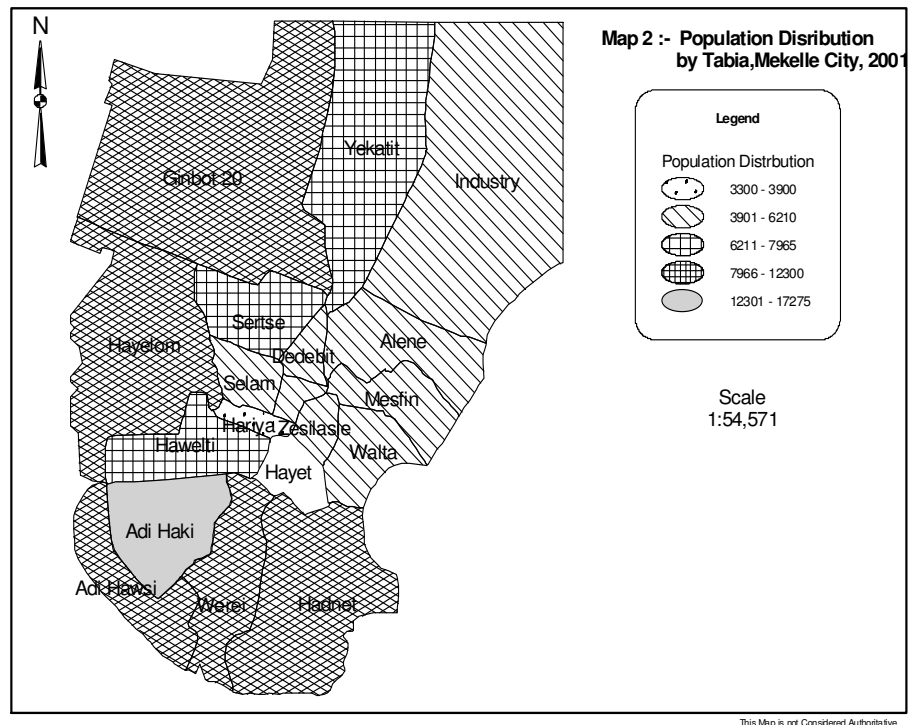
year 31323 students (15035 males and 16288 females) have been enrolled in the primary schools (grade 1-8). In the secondary schools about 6578 students (3583 males and 2995 females) in grade 9-10, and about 3680 students (2529 males and 115 females) in grade 11-12 have been accommodated. (Source: Bureau of Education).

Table 2. Number of households and population by Tabia, Mekelle, 2001

S. No	Tabia	Total No. of Household	Population size	%
1	Dedebit	1185	4503	3.39
2	Kedamay Woyane	1188	4514	3.40
3	Sertse	2040	7752	5.84
4	Ginbot 20	2460	9348	7.05
5	Yekatit	2039	7748	5.84
6	Industry	1421	5400	4.07
7	Alene	1178	4476	3.37
8	Mesfin	1182	4492	3.39
9	Walta	1548	5882	4.43
10	Selam	1242	4720	3.56
11	Hayelom	2823	10727	8.09
12	Zesilasie	1593	6053	4.56
13	Hayet	780	2964	2.24
14	Hadnet	2721	10340	7.79
15	Adi Haki	3455	13129	9.90
16	Adi Hawsi	2242	8520	6.71
17	Worei	3044	11567	8.72
18	Hawelti	1885	7163	5.40
19	Hareya	880	3344	2.52
	Total	34906	132643	100.00

Source: Health Office, Polio Eradication campaign

As regards the health facilities, there are one zonal hospital, two privately owned medium level hospitals, three health centers and twenty-six private clinics. Moreover, one specialized referral hospital is under construction. The pharmaceutical retail outlets found in the city are 7 pharmacies, 4 drug shops and 12 rural vendors. (Source: Health Office).



Finally, the economic overview of Mekelle indicates that there are considerable numbers of establishments that can have a direct impact on the quantity of solid wastes generated. In 1993 E.C there were about 256 wholesales, 1235 retails and 627 services.

At the end of the 1992 Fiscal year, among the service giving establishments, 95 were hotels, 31 pension, 69 restaurants, and 178 snake bars. Moreover, in 193 Fiscal Year, there were about 107 of both heavy and light industries in the city. (Source: Trade and Industry Office).

As it has been indicated in the development plan of the city, the poor environmental sanitation has been one of the severe problems of the city. These have no adequate sanitation facilities of both liquid and solid waste service. As a result the people dispose off their wastes, of both solid and liquid, anywhere in the city. And these have significant consequences on the environmental quality and on the health condition of the people of the city. Furthermore, the inadequate sewerage (drainage systems), strengthened by the nature of the topography of the city (sloping from the Endayesus upland), has exposed it to periodic inundation and flood risks. (Source: NUPI, 1993).

1.2. The Statement of the Problem

The collection and disposal service is one of the most important services provided in urban areas. Yet this type of service has been and continues to be the most neglected one in Mekele City. Of course, the Health office of Mekele city, which runs the solid waste management service (the collection and disposal service) has recently started to improve its service by introducing 20 public storages and 2 lifter trucks and not more than 3 used-tractor-carriages for door to door collection services.

Additionally the residents are mobilized from time to time to clean their immediate neighborhoods through collected efforts.

Nevertheless, all these efforts could not cope up with the rate of solid waste generation in the city. The piles of wastes dumped illegally on open areas, in gullies, river courses, etc. are undisputable evidences of the poor solid waste management system of the city. It is also not an unusual phenomenon to come across with wastes thrown away at every corner of the residential areas, in streets, shopping areas, institutional areas, etc.

The number, distribution, sitting and size of the public storage facilities is also another problem of solid waste management of the city of Mekele. The public storages are so few and unevenly distributed, irrespective of the density and optimum travel-distance of the beneficiaries. These public storages are placed (sited) either too far from or too close to the residential or working house. Another serious problem related with this storage is that they are not collected regularly; they take more time unnecessarily before they are collected.

The disposal sites and methods are also other problem areas of Mekelle's solid Waste Management Unit. The disposal site is located on the top of the upland area of Messebo. And this creates a strong challenge to the vehicles, particularly to the tractors to turn round across the steep road. The method of disposal exercised so far by both methods of collection is an unsanitary dumping technique, which has an impact on environmental, health and aesthetic condition of the near by settlements.

Besides, the resident's bad solid waste collection and disposing practices whether due to ignorance or negligence are exacerbating the problem of the poor waste management system of the city. In deed, a clear difference among the settlement areas (Tabias) is observed. Usually certain Tabias have never been get ride of wastes thrown here and there. This implies

that there is a wide disparity in attitude and practices among the Tabias residents regarding solid waste management activities (solid waste handling).

The consequences of this poor management of solid waste are greatly damaging the life of the city. The solid wastes left un collected everywhere are causing the closing up of the sewerage channels leading to spillage; creating unbearable odors, causing scarcity of open, clean play grounds for children, etc. In general, the environmental quality and the aesthetic and health conditions of the city are deteriorating. And, of course, as the city is growing fast, the problem is getting severe.

Thus, the purpose of the study is to examine the main factors that constrain the solid waste management practice in the city.

1.3 The Objectives of the Study

In view of the problems mentioned above, the principal objectives of this study are the following:

1. To examine the pattern of the generating, collection, and disposal of solid waste in Mekelle
2. To examine the extent to which the participation of the residents in solid waste management contributes to the city's cleanliness.

Specific Objectives

Some of the specific objectives of this study are:

1. To determine the solid waste generation rate (kg/capita/day) and thereby the total solid waste produced by households in the city.
2. To determine the total solid waste collection and disposal service coverage of the Solid Waste Management Unit as well as the public (cleanliness-campaign).

3. To identify the spatial pattern of solid waste generation and collection in the city
4. To assess the major social, economic, demographic and institutional factors that influence solid waste management in the city.

1.4. Research Questions

In this study an attempt is made to address the following key questions:

1. How much solid waste is produced by households in the city?
2. How much of the solid waste (produced in the city) is and could be collected and disposed by the Solid Waste Management Unit and by the public (through the cleanliness-campaign)?
3. Which part of the city is better served by the Solid Waste Management Unit? And why?
4. What factors do influence the city's solid waste management?
5. What are the legal aspects, if any, regarding solid waste management in the city?

1.5. Methodology

The Nature of the Data

This study is based on data obtained from both primary and secondary sources. The techniques employed to collect the primary data are field measurement, questionnaire, interview, and personal observation.

The project work was carried on to estimate the per capita domestic solid waste generation rate in a day and thereby to estimate the total quantity of domestic solid wastes produced in the city. For this I have used 30 sample units. The sample units are households, which are completely separated from any type of business activities. Taking in to consideration the significant variation in the rate of domestic solid waste generation, the 30

sample households were selected from three income categories: the higher-income, middle-income, and lower-income categories.

The questionnaire that provided to the sample households were filled by female members of household, and, where possible, by females responsible for house management. When the female selected to fill the questionnaire could not read and write properly they were requested to fill the questionnaire with the help of field assistants.

The questionnaires have been used to obtain data about the solid waste management system in general in Mekelle. Two types of questionnaires have been employed. The first was to be filled by the householders, and the other was intended for workers of the city's solid waste management unit. The questionnaires, of both types, are concerned basically with the quality of the service of solid waste management provided by the responsible body (mainly Health Office), and with the practices of the community of Mekelle as regards solid waste management.

The differentiation of the sample households by income level has been impossible because the majority were not willing to report their incomes. As a result, the writer has used housing conditions as a proxy variable in order to classify the sample households into three broad income categories. The most important aspect of housing that was used as an indicator of income in this regard is the number of rooms per dwelling unit. Accordingly households whose houses have 4 rooms and above, 2 and 3 rooms, and 1 room only have been designated as higher income, middle-income, and lower-income groups respectively.

The writer has achieved a significant amount of data about the solid waste management system in the city through face-to-face interview. Accordingly officials and workers who are involved in solid waste management have been interviewed. These include, the department heads, experts, supervisors and ordinary workers. Moreover, the residents who

are particularly dwelling very close to the containers have been approached for information. Relevant information has also been gathered by interviewing public administrators who were in charge of the day-to-day affairs of Woredas and Tabias

The last and best sources of primary data used in this study were the writer's personal observation. In as much as time and resources permitted attempts have been made to observe the condition of the container sites; the way the community utilizes the containers; the collection system and the frequency trips made by municipal vehicles to collect and dispose solid waste; the various areas in the city which are highly affected by illegal dumping of solid waste such as the river courses, open-areas, etc; the way domestic solid wastes are handled by individual households and the condition of the final disposal site of the city -the Messebo Disposal site.

As far as secondary data sources concerned, in addition to the numerous published and unpublished documents of the Health Office, the writer has taken data from various offices such as the CSA, the Regional Urban Development Office- Cadastre Unit, the Planning Office, the Trade and Industry Office, and the Public Administration Offices (Woredas and Tabias) of the Especial Zone of Mekelle.

Sample Design

For this study two different samples have been formed to collect the primary data; the first is the sample constituted these households selected to measure the domestic solid waste generation rate. The second sample is that of the individual households and workers of the solid waste management service who filled the different questioners.

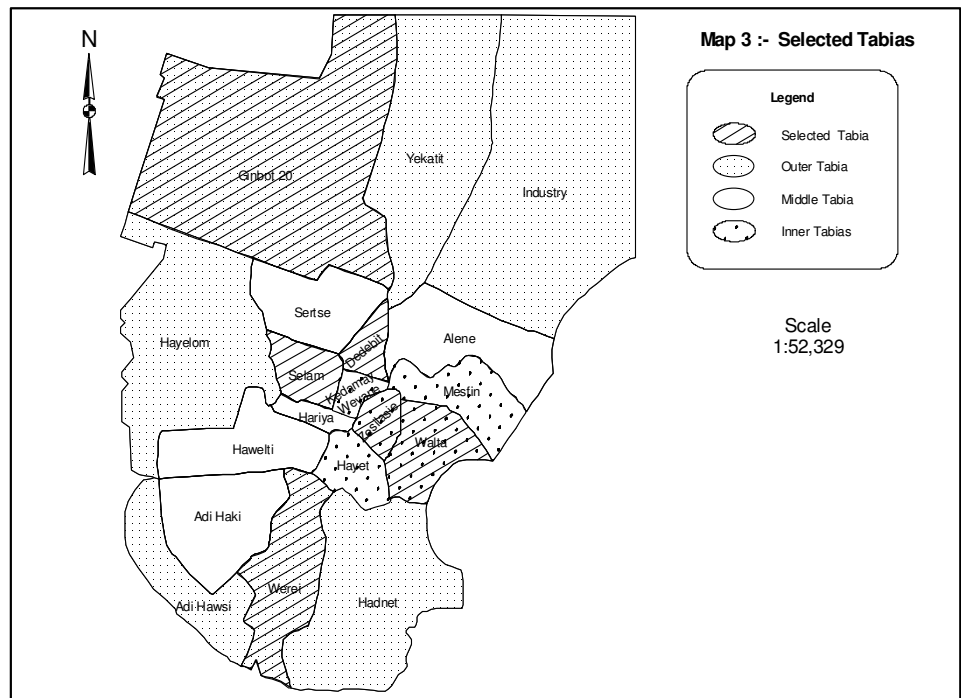
As regards the first sample, with the help of the Tabia Administrators, the writer purposely selected 10 households each from the three income categories that lie, as far as

possible, close to one another. Then the domestic solid waste produced by the 30 households in 7 days were collected and weighed. Out of the 30 households, the data of two households- one from the middle and the other from the lower income group- have been invalid for different reasons. Thus the actual sample size used in the study was 28 households.

The size of the sample households who fill the first questionnaire was 300. To select these households I primarily used the Tabia division of the city. Based on their relative proximity (location) to the center of the city I have tried to categorize the Tabia into three groups-the outer, the middle and inner Tabia as follows:

Outer	Ginbot 20* Yekatit	Industry Hayalom	Hadnet Adi Hawsa	Werei*
Middle	Debedit* Sertse	Alene Selaim*	Adi Haki Hawelti	Hareya.
Inner	Kedamay Woyane Mesfin	Walta* Zesilasie*	Hayet	

*Sample Tabias



Then using simple random sampling techniques, 6 Tabias, two Tabias from each group were selected. These were Tabia Ginbot 20 and Worei from the outer Tabias, Tabias Dedebit and Selam from the middle Tabias, and Tabia Walta and Zesilassie from the inner one.

In order to constitute a total sample size of 300 respondents 50 households were selected from each Tabia through a systematic random sampling method. The sample formed to fill the second questionnaire has been selected in two ways. To select the sample workers, the workers were categorized according to their duties, that is Container Guards, River Course Guards, street sweepers, drivers and their assistants of both types of vehicles (skip-loaders and tractors), Sanitary Guards and personnel (officers). Then 26 sample units (20%) were selected proportionally from each section through simple random sampling techniques. Questionnaire was distributed to the 26 sample workers. However 4 workers have not returned the questionnaires. Therefore, the sample size of the workers was 22.

Data analysis

To analyze the data I have employed various types of statistical techniques. These include both descriptive and inferential statistics. Tables, graphs, and percentiles (ratio) have been employed to organize and describe the data. Maps have also been used to show inter-container distances and thereby delimit the catchments areas of each container based on the beneficiaries' optimum-travel distance, and the distribution of domestic solid waste production by Tabia. Moreover, I have utilized a rank correlation method of analysis to measure the degree of correlation between facility distribution and quantity of domestic solid waste generated in each Tabia.

1.6. The Significance of the Study

It is hoped that this research work could have multi significance. Firstly, like most other research projects, it is hoped that it will contribute to the development of the literature in

the solid waste management aspect. It will particularly provide us with a clear picture about the specific features and problems of the solid waste management system of urban areas in developing countries, as Mekele is part and parcel of them.

Secondly, it will help the city's Health Office, Sanitation Section, to improve their working system. For example, they will be able to determine the quantities and kind of facilities, manpower size, and amount of budget required to run the collection and disposal service efficiently and economically, and to reconsider the distribution and the sites of the containers in the city.

Thirdly, this research work will serve as a springboard for comprehensive study on Solid waste management system in Mekele and other related topics.

1.7. Delimitation of the Study

The study has been delimited in space only to the geographical area currently under the effective administration of the special zone of Mekelle at least before 2001, which consists of two Woreda (Northern and Southern), divided into 19 Tabias.

In terms of scope, the study mainly refers to the solid wastes of residential origin domestic solid wastes. In deed, for the very nature of the municipal solid wastes in general, it has been difficult to treat them separately from other types of solid wastes in some aspects. However, in every possible way the domestic solid wastes have been exclusively treated.

1.8. Limitation of the Study

The writer believes that the study would have been better had there not been the following constraints

1. There are no data about the amount of (domestic) solid wastes generated and collected in the city of considerable number of years to make a trend analysis.
2. There are no recorded data about the amount of solid wastes collected and disposed of by the public (cleanliness- campaign) to estimate its contribution.
3. There are no recorded data about the amount of solid wastes collected and disposed off, by areas (Tabias) and source (origin) to make spatial analysis
4. It has been difficult to get information about the income size of households and the relative proportion of the number of households, whose dwelling houses have 4 rooms and above, 2 and 3 rooms, and only one room to estimate the average household's domestic solid waste generation rate.

CHAPTER TWO

LITERATURE REVIEW

2.1. The Characteristics of Solid Waste

The term "waste" is not as such an easy and a clear concept to define as well as to understand. Though, as Eduljee has indicated, terms like "useless" or "valueless" are commonly used in the dictionary definitions of waste, a legal definition of waste, depending on the existing situation of a particular country is necessary. For instance, the environmental protection Act 1990 (UK), in its definition of waste, has used phrases as 'scrap material or other unwanted surplus and any substance which requires to be disposed of as being broken, worn out, contaminated or other wise spoiled (Harrison, 1996:340). Moreover, it is difficult to identify (delineate) a clear boundary between "useless" and "useful" materials, which is permanently and universally functional. According to Bridgewater (1979:3) waste is defined as *"a material that is considered by the producer to have no value"*.

This definition has two implications. First, it is from the waste producer point of view that a material (or substance) is designated as "waste". Second, a material once designated as waste by its producer could be a resource for someone else in some way. There may not be a material (or substance) that could be useless or of no value forever and for everybody; it is only a matter of technology, economy and attitude of the society.

In deed, waste in general comprises a vast range of materials that is most conveniently classified by phase as gas, liquid or solid, and combinations of these. Many different scholars and experts have tried to define solid waste exclusively differently, but as far as its basic conceptual meaning is concerned all the definitions are somehow similar.

Edelman (1997) for instance indicated that any material might be considered (solid) waste when it exhausts its utility and it causes nuisance due to aesthetic and environmental reasons.

Another probably very comprehensive and more clear definition of solid waste is given by Tchobanoglous. Tchobanoglous (1993:8) defined, solid waste as

"all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. The term solid waste... is all-inclusive, encompassing the heterogeneous mass of throwaways from the urban community as well as the more homogeneous accumulation of agricultural, industrial, and mineral wastes".

But, as mention earlier, we have to be careful as regards the implications of the terms "useless" and "unwanted", since they can potentially miscommunication the real nature of the concept of 'solid waste'. Usually a tendency of relating solid waste with dirt, nuisance, lack of value, useless, unwanted, and cost of disposal. But it is in relative sense that solid wastes are considered as useless or unwanted. Because (solid) wastes which are of little or no use to the one who discards them could be useful in other settings, though not necessarily imply to all; someone also may use them as a vital resources in some other way. It is widely believed that solid wastes can be potential resources, for example, to produce compost (or Bio-fertilizer) or biogas, or to recycle and reuse them [Edelman, 1997:1].

Waste characteristically refers to the quantity, composition and types of solid wastes. For effective and economic management of solid wastes produced in a particular city, a considerable knowledge and data about the characteristics of the solid wastes of the respective city is a necessity. A waste manager, in order to decide or determine the types and quantities of facilities required for solid waste management and the best disposal options needed in a particular city, needs a precise information about the quantities (generation rate) and the nature

of the constituents (composition) of the solid wastes produced in the city. Even to plan for future provision of facilities, projected increases in quantities of each waste stream (source) should be estimated (Rushbrook, 1999).

For instance, the frequency of collection, the size and number of facilities (both waste storage containers and collection vehicles), the capacity of landfill, and number of labour forces required are highly dependent upon the rate of generation of solid wastes. Whereas the composition-the nature of the components, of solid wastes generated in a city determines mainly the best method of disposal option; whether to use composting, recovery and recycling, incineration or mere land-filling (or dumping) depends upon the nature of the constituents of the solid wastes.

The characteristics of solid wastes generated vary over place and overtime as well. The quantities (rate of generation) and composition (or types) of solid wastes vary from region to region, from city to city and even from community to community within a city, as well as from time to time depending on a number of factors. Some of the main factors that influence the rate of generation and composition of solid wastes, for instance, as indicated in World Health Organization in 1976 (as cited in Rushbrook) include the number of population, the standard of living (economic status of the people- average level of income of the people), the social and religious customs of the people, attitude of the people, physical characteristics of the city (e.g. climate and seasonal variation), the sources (origin) of the wastes, and the public health-awareness (Rushbrook, 1999, and Edelman, 1997).

As economic prosperity increases the quantity (amount) of solid wastes generated increases in both weight and volume, and the nature and the relative proportion of constituents of the solid wastes change. Therefore, the rate of waste generation (kg/ capita/ day) of higher income countries (groups) and lower-income countries (groups) vary very significantly. For

example, according to the results of 1982 survey, the waste generation rate of the lower-income countries (countries having per capita income of less than US \$360) and higher income countries (countries having a per capita income of more than US \$ 3500) was 0.4 -0.6 and 0.7-1.8 kg/ capita /day respectively. While for the Middle-income countries, which lies between these two extreme income groups, the solid waste generation rate was 0.5-0.9kg/capita/ day (Rushbrook, 1999).

Other similar studies, United Nation Center for Human Settlement (Habitat) (UNCHS), show that the country wide average rates of waste generation in most industrialized countries lie between 0.8 and 1.4 kg/capita/ day. Where as the developing countries usually generate the smallest quantities of waste of the average city-wide rate; sometimes, it is as little as half the city-wide average (UNCHS, n.d).

Similarly, the average income level of society affects the composition (both physical and chemical) of solid wastes generated. Typically, individual components (items) of municipal solid wastes include food (putrescible) wastes, paper, plastics and rubber, textiles, leather, cardboard, wood, bones and straw, metals, glass and ceramics, ashes, particles of 10mm size, etc. The type of individual components and their relative proportion in society of different income groups vary significantly. Luxury wastes (combustible rubbish) such as paper, cardboard, plastic textiles and heavier organic materials proportionally constitute larger part in higher-income groups (countries) than in lower income countries (or groups). Where as putrescible items like garbage and ashes constitute a predominant proportion of the municipal solid wastes in less developed countries (in lower income groups) (Rushbrook, 1999, Edelman, 1997, and Tchobanoglous, 1977 and 1993).

The impact of population size on the characteristics of municipal solid wastes, particularly on the quantities of solid wastes generated is very high and direct. Obviously,

when there is an increase in the population size, there will be an increase in the total amount of waste generated, even if other variables remain the same.

Moreover, other aspects of (solid) waste characteristics like moisture content (that is, the percentage of the weight of wastes which is water), the biodegradability (that is, the proportion of biodegradable material in the total wastes), calorific value (the amount of heat energy that can be produced if all the combustible components of the waste are burned) and densities (the weight of waste as per unit volume) of the solid wastes have not a least impact on the planning and operation of solid waste management. An adequate knowledge (information) about these and other characteristics of waste produced in a particular urban center will also help an urban manager of the respective urban center to identify, select suitable waste treatment processes, storage and collection facilities, disposal methods, and disposal sites (Rushbrook, 1999, and Tchobanoglous, 1977, and 1993).

Types of Solid Wastes

Virtually, solid wastes can be classified into different classes based on either their origin (sources) or on the nature of their components. On the basis of the nature of the items that constitute the solid wastes (composition), solid wastes can be classified into organic or inorganic, combustible or non-combustible, and putrescible or non-putrescible. While according to the sources from which they emanate, (the types of) solid wastes are usually classified as domestic (household), commercial, industrial, institutional, street sweepings, and construction and demolition wastes. But sometimes scholars classify solid wastes based on their origin into three general classes: municipal (which includes domestic waste, street side waste, commercial waste, market waste, and hospital waste), industrial, and agricultural and animal wastes (Edelman, 1997).

According to the system of classification of Rushbrook in 1999, and International City Manager Association in 1957, residential (also termed "domestic" or "household") solid wastes refer to the wide variety of wastes produced by residents in houses and apartments. These include the wastes that are produced from household activities (such as food preparation and consumption, sweeping, cleaning, fuel burning, and garden wastes), and used items like old clothing, old furnishings, abandoned equipments, packaging, newsprint, etc. This class of wastes, in the lower-income countries is dominated largely by food and ash wastes, though plastic packaging is increasing, while in middle- and higher -income countries, items like paper, plastic, metal, glass and discarded manufacture items constitute the highest proportion. Moreover, household/ residential solid wastes consists of the highest proportion of municipal solid wastes- for instance about 75% in developing countries (UNCHS, n.d.:3).

Commercial wastes refer to wastes from shops, restaurants, hotels, and similar commercial establishments. Industrial wastes are wastes produced by industries. Since large proportion of industrial wastes arises from chemical operations and uses, they are usually termed as "hazardous" industrial wastes" or "special wastes".

Institutional waste include solid wastes produced in different types of establishments such as offices, schools, hospitals and other health care institutions, military bases, and religious buildings. Street sweepings are almost always dominated by dust and soil together with varying amounts of paper, metal, leaf and similar litter that is picked up of the streets. Construction and demolition waste, though its composition depends largely on the types of building materials used in a particular city, includes items like soil, stone, brick, wood, clay, reinforced concrete and ceramic materials. Still some other scholars and experts may classify solid wastes in different ways into different classes. But traditionally, and of course more

functionally municipal solid wastes can be classified into three main classes: residential/household, commercial, and industrial solid wastes (Rushbrook, 1999:17).

Though most of them are not in any case synonymous to the concept of 'solid waste', different terms have been widely used instead in different readings and literature, such as refuse, garbage, rubbish or trash.

But usually both terms "refuse" and 'solid waste' are used synonymous. Most commonly the term "solid waste" is used as a matter of preference (Davis, 1991).

2.2. The Problem of Solid Waste Management

Solid wastes are greatly the products of human activities. It might be almost normal to come across some form of wastes from almost all types of human activities. It might also be difficult and even a futile attempt to eliminate or avoid completely the creation of wastes. This implies that the production of wastes is inevitable and its disposal is necessary.

As soon as wastes are produced, the primary concern of the waste producer is what he/she can do with his/her waste. Then, he/she often thinks about possibilities how he/she can easily get rid of his wastes, with little concern to either the economic and attractiveness of the alternatives, or to their consequences (Bridgewater, 1979:11).

Indeed, many of the individual items of the solid wastes by themselves may not be a direct threat to human life. However, *"it is the ways these wastes are (or are not) handled, stored, collected and disposed that can pose risks to public health"* (Rushbrook, 1999:XV).

Therefore, if wastes are left uncollected in residential and working areas or improperly disposed of, they may

"cause nuisance due to aesthetic and environmental reasons, they may cause and spread diseases by harboring pathogenic microbes and rag pickers. They can also contaminate land or water and emit foul odors" (Edelman, 1997:1).

Solid wastes are particularly accumulated in urban areas And the problems related to solid wastes in urban areas are increasing in scale and complexity from time to time mainly due to the increase in the quantities and varieties of solid wastes generated, which in turn is the result of the increase in the size of population, the rise in the standard of living of population, and the expansion of industries (industrialization). Munasinghe has tried to show the problem of solid wastes in urban centers and according to his explanation. The high rate of urbanization, industrialization and an over-all economic growth are creating a tremendous challenge of millions of tons of waste to cities and cities throughout the world. Cities are heavily confronted with the tasks of managing the increasing accumulations of both municipal and industrial (usually hazardous) solid wastes. Despite the fact that municipalities are spending a large amount of funds on solid waste management, cities and cities cannot acquire an efficient, reliable, regular, and universal collection and environmentally safe disposal. As a result, the public health and environmental cost have been severe (Sarageldin, 1995:79).

Therefore, it is almost unlikely to secure clean and healthy living conditions in cities, and villages without reliable and regular waste collection and disposal services. Obviously, the dramatic increase in the quantities, and varieties (compositions) of the constituents of solid waste generated associated with the rapid urbanization and industrialization has made the establishment and development of an efficient and economical system of solid waste management necessary. The term 'solid waste management' comprises two important concepts: 'solid waste' and 'management'. The term solid waste has already been defined in the previous sections of this chapter. The literal dictionary meaning of the word 'management' is the control and organization of something (Cambridge International Dictionary of English, 1995). Where as the term "solid waste management", which merged the two terms- 'solid waste' and 'management; is defined by Tchobanoglous (1977:19) as:

"that discipline associated with the control of generation, storage, solid collection, transfer and transport, processing, and disposal of wastes in a manner that is in accord with the best principles of public, health, economics, engineering, conservation, aesthetic, and other environmental conditions, and that also is responsive to public attitudes."

It is indicated that solid waste management is a multi disciplinary activity. Thus, so as to bring about solutions for solid waste management problems, a joint work of many fields including geography and city and regional planning. The problem of solid waste management, particularly in the developing countries, is more complicated by the inadequacy of the financial resources for operation; the inappropriateness and shortage of technologies and equipments used; the inefficiency of the responsible agencies/ institutions either due to weak and/or inappropriate organizational structure, or poor management and planning system; and the lack of community participation (Edelman, 1997).

The provision of satisfactory solid waste collection and disposal services to the public (or solid waste management in general) is hindered by so many obstacles. Some of the major obstacles, as described by Rushbrook (1999:3), are:

- " - Inadequate residential waste storage facilities*
- Shortage of waste collection equipments/ trucks and containers caused by rapid increases in waste quantities*
- In efficient waste collection and disposing due to inadequate forward planning and poor truck maintenance*
- Unsanitary disposal practice with open dumping*
- Increasing difficulty in acquisition of land for disposal*
- Inadequate use and improper management of contractors or public sector labour*
- Inappropriate location of landfill disposal site*

- *Inadequate waste recovery*
- *Inadequate forward (strategic) planning capacity"*

It is well accepted that the quantity and variety of solid wastes produced in developed countries is by far larger than in the developing countries. However, the problem of solid waste management has, for a number of reasons, been and continues to be more severe in the developing countries. To indicate the problems of developing countries associated with solid waste management, Munasinghe noted that solid wastes are increasingly accumulated particularly in the developing countries. However, these countries have not yet adopted improved solid waste management technologies. Moreover, solid waste management has not been given priority in the policy of developing countries because the governments of these countries are unable to understand and appreciate the strength of the negative effect of the inadequately managed solid wastes to human health and the environment (Sarageldin, 1999:79).

The services of collection, transfer and disposal of solid wastes in the urban areas of developing countries are either sparse or ineffective and/or the wastes are often improperly disposed of. About 30% to 50% of the solid waste produced in urban areas in the lower-income as well as poorest parts of middle-income countries is estimated to be left uncollected (Sarageldin, 1995, and Rushbrook, 1999).

As a result, the millions of tons of solid wastes generated daily by the residents, industries, commercial establishments, and institutions left uncollected are causing severe repercussions-the death of millions of children and adults. Moreover, the uncollected solid wastes are creating problems at the community level- clogging of drains, releasing foul odors and toxic gases, and spreading diseases. The waste problems worsen as the urban areas grow which exacerbates the direct effects on health. But, a particular groups of the society are

relatively affected more severely by the mal-management of solid wastes that ranges from municipal workers (who collect and dispose of the garbage) to the scavenging families who live in and work at the dump site. But generally urban poor are the most affected groups of the population (Sarageldin, 1995).

It is estimated that less than 20% of the wastes produced in the developing countries is treated (or processed), of which only a small proportion meets acceptable standards. And according to the prediction of some experts, about half of the urban population in developing countries was estimated to have no adequate waste disposal by the end of the 20th century (Sarageldin, 1995).

Davis has summarized the main objectives of the solid waste management into two. Firstly, it is

"to remove discarded materials from inhabited places in a timely manner to prevent the spread of disease, to minimize the likely hood of fires, and to reduce aesthetic insults arising from petrifying organic matters." Secondly, it is "to dispose of the discarded materials in a manner that is environmentally acceptable" (Davis, 1991:80).

In order to achieve these objectives and generally to improve solid waste management system, Rushbrook has suggested the following activities:

- Improving *public health and environmental protections*
- *Expansion of waste collection to areas not currently serviced and involvement of the private sector*
- *Improvement of organizations, resources and technical skills to achieve cost savings and efficiencies*
- *Improvement of cost recovery from waste products*

- *Upgrading the standard of land disposal of waste to make landfill last longer, operate more safely and reduce existing on-site problems"* (Rushbrook, 1999:3).

2.3. The Functional Elements of Solid Waste Management System

This refers to the various activities involved in the solid waste management from the point of generation up to the final disposal its. As the problems associated with the management of solid wastes are getting more and more complex because of the quantity and diverse nature of the wastes and some other reasons, a clear identification and understanding of the different aspects/ functional elements and their inter-relationships would be necessary so as to efficiently and orderly manage the solid wastes.

For practical purpose (as for a waste manager) as well as academic purpose, the identification of the activities associated with solid waste management and classifying them phase by phase is very important and helpful because, this will help to identify and understand clearly the obstacles associated with solid waste management and improve them efficiently, economically as well as timely. The activities (functional elements) may be identified, arranged in logical sequences, as waste generation; on-site handling, storage and processing; waste collection; transfer and transport; processing and recovery and conversion products; and disposal. But obviously certain phases could be in active.

2.3.1. Waste Generation

Waste generation refers to all activities of identification of materials as no longer being of value and thus are either thrown away or collected for disposal. This identification of a material as a waste varies with each individual. This aspect of solid waste management system is not usually recognized as functional element standing on its own for it is not very

controllable. Yet it is a critical phase that determines extremely the activities of all the subsequent functional elements. In other words, there is a strong interdependence between waste generation and the other functional elements, and this is known as systems continuity, (Tchobanoglous, 1977, and UNCHS, n.d.).

From the management and planning stand point, the rate of generation affects the number and type of storage containers, frequency and method of collection and the capacity of disposal sites required in a given urban area. Therefore, as a preliminary activity of the solid waste management, a waste manager/ administrator has to be able to identify the sources and types of solid wastes: to examine the physical (and chemical) composition of the solid wastes, to measure the waste generation rates and identify the influencing factors. A detail, precise and up-to-date information regarding the variables are very helpful for efficient solid waste management.

Moreover, there is a room for the reduction of the quantities of solid wastes generated. By applying different mechanisms including incentives and disincentives (carrot and stick), it is possible to influence both the producers of the materials and the consumers of the products to avoid or minimize the quantities of waste generation. In fact, the activities of waste generation are highly dependent upon the individual preferences, and this makes it difficult to control and to manage this phase. Thus, whether to avoid, or minimize or even to sort waste materials at its source requires active participation of the waste generators, including householders and commercial and industrial companies and their employees (Harrison, 1996:348).

2.3.2. Onsite handling, storage and Processing

The activity associated with the handling, storage and processing of solid wastes at their source is very important in the solid waste management system since it greatly affects the public health, the subsequent functional elements and the public attitudes towards the operation of the system as a whole. Generally, when solid wastes are properly prepared and stored on containers, the collection of the materials can be regular, in expensive, and sanitary. But if the reverse condition happened, the collection expense may be extremely high and it is quite probable that the service will be generally ineffective and unsatisfactory (International City Manager Association, 1957).

On-site handling

This exclusively refers to the activities associated with the handling of solid wastes until they are placed in the containers used for their storage before collection. The handling of the solid wastes at their sources is mainly the onus of the generator (producers). Thus the persons responsible for on-site handling, the auxiliary equipments and facilities used, and at the methods of handling of wastes at the source vary by types of waste sources and by the socio-economic condition of the residents. For residential wastes, for instance, the residents themselves (the children, householders) or tenants are usually responsible persons for placing the wastes generated in and around their dwellings into the storage containers.

Onsite Storage

The consideration of the onsite storage of solid wastes is important for the betterment of the system from the point of view of identification and understanding of the types of containers to be used, the location (or sitting) of the containers, the impacts on public health and aesthetics, and the collection methods to be used. To a large extent, the quantities and

nature of the storage containers depend on the characteristics of the solid wastes (that is, the rate of generation, the physical and chemical composition, the moisture content of the wastes, etc), the collection frequency and types of collection equipment, and the space available for the placement of the containers (Tchobanoglous, 1977 and 1993, UNCHS, n.d., International City Manager Association, 1957).

In fact, in residential areas of lower-income community, it is possible to classify the onsite storages into two: the primary and the secondary storage container. It is not uncommon to find very small, temporary or relatively permanent, receptacles of different types and quality within and around individual home owned privately where wastes are placed on as soon as they are produced. These receptacles are of varied types and capacity and have no standard, which depend largely on the economic standard and attitudes (awareness) of the residents towards solid waste management. In other words, the choice of the type of receptacles depends on the preference of the individual (Tchobanoglous, 1977 and 1993, UNCHS, n.d., International City Manager Association).

The location (or sitting) of containers, though usually, it may be carried on haphazardly or randomly, needs thorough considerations with respect to the public health and aesthetic, the availability of space for placement, accessibility to the beneficiary (optimum travel-distance), access to collection vehicles, and generation rates (or population density).

Onsite storage can potentially have significant impact on the public health and aesthetics. Generally, the management issue and concern associated particularly with onsite storage is 'the ease with which the people can move, accumulate, and discard heterogeneous wastes'.

Onsite Processing of Solid Wastes

Onsite processing possibly occurs (takes place) any time before collection, whether before, during or after storage. This may involve various methods such as grinding, sorting (separation), compaction, shredding or composting. The processing of solid wastes specifically at their sources and possibly at any functional elements includes may involve reducing the volume of the solid waste that is ready for collection and disposal; altering physical form of the solid wastes such as to reduce the size of the individual items or/and recovering usable materials from solid wastes

The processing of solid wastes at their sources may be carried on by residents (generators), rag pickers (scavengers) or private enterprises.

Of course, residents active participation is well recognized for the successful operation of solid waste management system; each resident in the community can and should contribute much to it by utilizing proper storage of solid wastes at homes, maintaining onsite conditions, sorting wastes for recovery, etc.

2.3.3. Collection of Solid Wastes

Solid waste collection (the third functional element) involves the gathering (or picking up) of solid wastes (and possibly recyclable materials) after collection, from the various sources as well as the transport of these wastes, to the area(s) where (the contents of) the collection vehicle is emptied. Solid waste collection services could be provided by either municipality, private companies under contract to a municipality, or by private companies/enterprises individually engaged by homeowners. Even though each of these agencies/enterprises has inherently certain pros and cons, the waste collection service in a city could be

performed either by the three bodies simultaneously, by two bodies or by only one body (agency) (Hagerty, 1973, International City Manager Association, 1957).

The waste collection services in a particular urban area, no matter whose responsibility it is depend upon several factors. Hagerty (1973:46) grouped these factors into two: the relatively unchanging (relatively permanent), and variable factors. The relatively permanent ones, includes the population distribution and density in the collection area the climatic factors, the characteristics of wastes produced in different sections, etc. While the second groups, variable ones, include the disposal methods which are currently being used in that community, the available type of collection equipment, the customary collection frequencies in various areas, and the overlap and extent of responsibilities among municipal, contract and private companies, and the traditional or required labour practices in the given area.

Collection Systems and Equipment

It is noted that a wide variety of solid waste collection systems and equipments have been and can be used. And the classification of solid waste collection system may be made on the basis of either the mode of operation, the equipment used, or the types of wastes collected. The collection system can be classified in different ways based on their mode of operation, types of equipments used, types/nature of wastes, etc. For instance, it is possible to distinguish between two types of container systems: Hauled and Stationary. Usually the former for it uses large containers are usually used in areas where there is high rate of generation and are more economical. However, since they are filled manually either low volume of utilization or misuse of the large containers become common phenomena.

The United Nations Centre for Human settlement (Habitat) has classified the collection systems practiced particularly in developing countries under four headings:

1. Communal Collection, 2. Block Collection, 3. Curbside Collection, and 4. Door-to-door Collection. (UNCHS, n.d: 11).

Each of the four methods presented above does have certain advantages and disadvantages. Thus, for most economical and productive collection of solid wastes for different communities in urban areas, often the use of a combination of these methods is advisable.

The many variations in the local conditions cause the problems of solid waste collection vary from community to community. So it might be impossible to lay down any hard-and-fast ruler on the best plan or arrangement for solid waste collection services. Thus, it is the onus of the waste manager/administrator to recognize and appreciate the local differences and then make selections of collection methods and equipment (International City Managers Association, 1957: 343 UNCHS, n.d.).

The multiple and diverse equipment and workforce programs, mechanization of collection operations, and labour efficiency and customer service levels, frequency of collection and location of containers, and the analysis of collection system; that is, the unit time required to perform each task are the major management concerns. Then collection routes must be laid-out so that both workforce and equipments are used effectively. Moreover, a (master) schedule for each collection route, on which the location and order of pick-up point to be serviced are found, should be prepared for use by the transportation dispatches and drivers (Tchobanoglous, 1977).

2.3.4. Transfer and Transport

This involves the transfer of wastes from relatively small sized and large number collection vehicles to large vehicles and to transport them over extended distances to either processing centers or disposal sites. Therefore, primarily, waste is collected by a large number of small

collector trucks and crews and is brought to a central location (in essence transfer station). Then, the collected waste is hauled to an ultimately disposal site in larger trucks which are especially suited to the long-haul operations (Hagerty, 1973:49).

Whether to use a transfer station or not in a solid waste management system, the distance of the disposal sites or processing centers and the capacity of the collection trucks are, among others, the most widely dictating factors. When the disposal sites or processing center are so far away from the collection routes (points) or sources of waste generation, and a large number of small-capacity collection trucks and crews are in use, the use of a transfer station becomes a necessity.

The transfer stations may have additional functions; different types of processing and recovery activities, such as separation (sorting), compaction (to reduce volume), recovery of usable items (salvaging), etc. can be carried on with in the station.

2.3.5. Processing and Recovery

Some of the (most) common techniques of solid waste processing applied in one way or another in solid waste management systems are volume reduction-mechanically (compaction) as well as and chemically (incineration), mechanical size reduction (shredding), component separation/ sorting (manually and mechanically), and drying and dewatering (moisture content reduction). When the volume and size of solid wastes is reduced using different processing techniques, the number of storage containers requirement, the frequency of collection vehicle trip to the disposal site and thus haul costs, can be effectively reduced. Even the land of the disposal sites could be used effectively. As a result, a significant savings in cost can be achieved (Hagerty ,1973).

However, despite the enormous benefits achieved from the processing and recovery of waste materials, practically it is usually un preferred alternative due to either lack of sufficient demand, the complex mixture of the materials in municipal waste which is too expensive to recover, or the like (Moran, 1986).

Bridgewater (1979:7) noted that whether to choose recovery of valuable materials or disposal option depends mainly on the three factors: technology, economics and attitude. Nevertheless, despite the great economic benefits of processing and recovery of valuable materials of solid wastes, convenience and attitude extremely influence both the sold waste producers and the users of recovered materials. 3). In his conclusion, Bridgewater (1979:7) said, *"even when recovery is technologically, economically and commercially viable, it is sometimes ignored for one of a range of reasons, including prejudice, stigma, politics, apathy, self-interest and conscience"*.

2.3.6. Disposal of Solid Wastes

Once the solid wastes have been collected and have already designated as having no further use for the society, it inevitably causes us to raise a question 'where shall it go?' Obviously, the only remaining option/ with respect to these wastes is disposal, which is the final functional element in the solid waste management system. Disposal is he ultimate fate of solid wastes collected from residential area, and residues from the various processing plants (facilities) that have no further use to society (Tchobanoglous, 1977).

And of course, it is difficult to avoid the health and social problems associated with solid wastes unless these wastes are disposed off properly.

The two most common methods of solid waste disposal that are currently widely practiced are open dumping and landfilling. But from the environmental, public health and

aesthetic standpoint, 'sanitary landfill' is a fully approved, controlled method of disposal, while 'dumping' is a completely uncontrolled and not accepted. Even though open dumping is the world's most common disposal method, no amount of careful collection or treating of waste will reduce the hazards to health and the environment from disposal if the final resting place for waste is an open dump. Open dumping is a generator of ill health ((Stirrup, 1969:16, and Rushbrook, 1999:xvi).

The selection of a site is very important concern of solid waste managers /municipal authorities because a poorly chosen site may require unnecessarily high expenditure on waste transport, site development, site operation or environmental protection. In order to identify a suitable site a wide range of criteria can be applied. Rushbrook (1999) grouped these site selection criteria under four aspects: transport related, natural conditions, land use, public acceptability, and safety.

Other scholars propose different selection criteria for the operation and development of sanitary landfill. Hagerty (1973:179) noted that a preliminary survey is necessary to collect information/ data about

- " 1. The types, characteristics and amounts solid wastes generated in the area to be served by the proposed landfill
2. The over-all economics of the land filling operation as compared to other methods
3. The over-all availability of land for a sanitary landfill operation
4. The factors of public acceptance of the sanitary land filling operations".

The role of the public participation and acceptance in the process of site identification are highly stressed by many scholar. In order to secure a public support (acceptance) educational campaigns are necessary, to make the population aware of the benefits gained in

land-filling-low cost of disposal, no pollution of air, land and water and future use of the land (Hagerty, 1973:179).

2.4. Rules, Regulations and Education of Solid Waste Management

Many, if at all, scholars and experts well recognize the enormous (great) role of community (waste producers) in the effort to manage solid wastes. Community's commitment to strengthen the operation of solid waste management system may not be only helpful but also it is a preliminary condition. In recognition of the advantage of community participation, Hagerty (1973: 279) said, *"since solid wastes are generated by the entire population, by all segments of society, any solution to the problem of solid wastes must arise from and be supported by that same population"*.

But parallel to this, ordinances, rules and regulations together with their accompanying penalties for violations, have rightful places in solid waste management operation. Practically all administrators agree that the cooperation of citizens can be secured more easily through education and persuasion than through the enforcement of laws and regulations. In order to achieve public support and participation in waste management, the first educational step has to be to make the people aware of the scope, magnitude, and severity of the solid wastes crisis prevailing in the urban area where they live (International City Managers Association, 1997:332, and Hagerty, 1973:275).

However, International City Manager Association (1997:332) noted that

"it is always desirable to have the necessary ordinances on the books to define proper and improper action and to provide the means of compelling habitual violators to follow the rules".

The ordinances, as described by the International City Manager Association (1997:333), include, among other provisions and specific requirements, the following points: separations required by household, provision of containers, location of containers, specification for containers, frequency of collection, limitations on quantities that will be acceptable, kinds of properties that will not be served, classes of solid wastes not accepted, control of private collectors, control of scavengers, provision against littering public property, control of dumping areas, administration and supervision provision, and enforcement powers and penalties. So it is necessary to devise enforcements.

As a result, whenever there is no public cooperation, unsightly appearance will prevail throughout the community, Therefore, the cooperation of citizens has to be secured through public education (International City Manager Association, 1957).

2.5. Solid Waste Management In Developing Countries

UNCHS (Habitats) in its report entitled 'Refuse Collection Vehicles for Developing Countries' has tried to identify some of the major problems of urban areas of developing countries associated with solid waste management services. The report focused particularly on the choice, operation and maintenance of solid waste collection vehicles.

The report indicated that, though it absorbs a considerable proportion of municipal effort, budget and workforce, solid waste management service in the cities and cities of developing countries is significantly deficient , and many areas within these urban centers are receiving little or no attention. UNCHS, while explaining the problem of the developing countries urban centers briefly, said,

"Rapid urban growth and stagnant economics, over recent decades, have strained administrative capacity, reduced service coverage Urban solid

wastes management services have consistently failed to keep pace with demand, and the insidious social and health effect of this neglect is greatest among the poor sectors of urban population" (UNCHS, nd.3)

The UNCHS's report show that solid waste management is one of the most costly urban service to provide where it absorbs up to 1% of the GDP and 20 to 40% of municipal revenues in developing countries. With respect to the utilization of workforce, by employing about 3-6 workers per 1000 population, between 1 to 2% of the national workforce of the developing countries could be engaged in the provision of solid waste management service. But, even though this is so the case, the service is frequently inadequate; more than 50% of the solid waste generated in urban areas remains uncollected, and large areas of cities are receiving no regular attention. For instance, in India more than 60% of the 34 municipalities, collected less than 40% of the waste generated. Similarly, in Karachi-Pakistan, Rangoon-Burma, Arusha-the Untied Republic of Tanzania, and Cairo-Egypt, it was only 33,40,13, and 50%, respectively, of the solid waste generated that was collected. Always, the majority of the population who hardly receive the solid waste management services live in low-income settlements (UNCHS, n.d:3).

Therefore, in the absence of regular solid-waste collection system, the wastes left uncollected are dumped in open spaces, on access roads and along watercourses. To make it worst, the dumps are invaded by scavengers and animals, which scatter the wastes, and as high as 30,000 population served per collection vehicle (UNCH; n.d: 3)

Often the provision of solid waste management service is the onus of the local governments. And the basic deficiency of these governments is failure to assume their responsibility to raise sufficient funds to provide an acceptable service. But even though the fund available for solid waste management service is limited, it is usually used to acquire inappropriate and inadequate equipments or to maintain insufficient, obsolete collection fleet.

As a result, as UNCHS report indicated, the solid waste management services in the developing country cities and cities can be characterized by unreliable, irregular and inefficient. And the wide range of financial, institutional, technical and social factors are recognized to be responsible for the low level of coverage and poor service common in many urban centers of developing countries.

UNCHS in its report described the following major problems of solid waste management in developing countries: " 1. Inadequate resource mobilization, 2, Over-reliance on imported equipment, 3. Inappropriate method of finance, 4. Use of inappropriate technology, and 5. Inequity in service provision" (UNCHS, n.d.: 5-6).

It indicated that the urban poor are largely excluded from any access to solid waste management services. But even the poor areas, which are assumed to receive services, the level of the service they achieve is much lower than that provided to the middle- and higher-income areas. However, it is evident that the need for the service is greatest in the low income communities because usually they have high population densities, and these sectors of the community are not well aware of the crisis of poorly managed solid wastes.

2.6 Solid Waste Management in Addis Ababa

This review of the solid waste management system of Addis Ababa is based on the paper of my study for the course Goeg.602. The study has generally indicated that there was inadequate, poor solid waste management in the city. And this has been due to the inadequate solid waste management service and bad piracies of the community associated with solid waste management. This implies that both the solid waste management department (health Bureau) and the community of Addis Ababa are responsible for the existing poor solid waste management in the city.

The solid waste management service of Addis Ababa has been organized under the Health Bureau since 1986 E.C. And since 1993 E.C it has been organized at a Department level. The Solid Waste Management Department of Addis Ababa has four main units: the Landfill Management, Collection and Transportation, the Public Toilet Service and Administration and Finance Service. It has extended its structure down up to the Woreda level though in decreasing order of responsibility and power.

The characteristics of solid wastes

This has dealt with the composition and rate of generation of the solid wastes. The only sources of data of the department in general is the survey results collected by two foreign agencies at different period of time: The Nor-consultant in 1984 and Gordon in 1994 and 1995. These studies has shown that the organic matter (kitchen wastes) constitutes for about 8%, recyclable item (like leather, glass, metal, textiles, paper, rubber, wood and plastics) for about 10%, combustible items (grass, leaves, etc) about 20%, non -combustible 3%; ashes 28% and fines 39% by weigh. And about 60% of the waste by weigh can be distinguished as organic matter that include kitchen waste, vegetable, organic fines, and grass. The constitutes like grass, leaves, bone organic fines, vegetables and fruits constitute about 90% of the city's solid wastes by volume.

Generation rate

The study shows that the solid waste management department has tried to estimate the total quantity of solid waste produced in the city based on the generation rate indicated by Nor-consultant and Gordon. The solid waste generation rate of Addis Ababa was estimated as 0.267 kg/capital/day. Then based on this rate and taking the total population of Addis Ababa as 2.7 million, about 720,900 kg by weight or 1948m³ by volume of solid wastes was

estimated to be generated in a day in the year 1993 Fiscal year; and about 711158m³ by volume or 263,138,460 kg by weight of solid wastes was generated in 1993 Fiscal Year.

However, it has been argued that the rate of generation assumed for Addis Ababa (i.e. 0.267 kg/capital/day) has been underestimated. It is far below the rate indicated by the World Bank sponsored international studies where the average rate of solid waste generation of the lower income countries of the world ranges between 0.4 and 0.6 kg/capital/day (Rushbrook, 1999).

The estimation of the solid wastes by origin shows that domestic solid wastes constitute the largest proportion (75%) followed by commercial solid wastes (9%) in Addis Ababa.

Service Provision

Container Services

The Addis Ababa solid waste management department has made use of two types of containers: the 8m³ and the 1.1m³ bins. Out of the 513 of 8m³ containers, 327 have been distributed in residential areas, and the rest 173 are provided to commercial establishments, industries and institutions. This implies that the residential areas, which generate about 75% of the total solid waste of the city, are served by about 63.9% of the total large (8m³) containers.

The 1.1m³ containers introduced to the city recently basically for sale, to industries, enterprises, institutions and even to residents. Of the 1200 of 1.1 m³ containers, only 501 (41.75%) were sited along the sides of the main roads to serve the community of free charges in 1993 E.C.

As regards the distribution and sitting of the containers, it has been found that though the Department has claimed that containers are sited with in 100-150 meters of walking distance from the source, the containers are sited (located) far apart. The beneficiaries are

happened to travel longer distances to get container service. This is partly due to the shortage of containers and problems in string of the containers. Consequently, the dumping of solid wastes anywhere in the city illegally by the community has been a common phenomenon.

Solid Wastes Collection and Transportation Service

The Solid Waste Management Department is the only agency which is governmental, involved in solid waste collection and transportation service provision. But very little community based private enterprises involved in collecting solid waste from door to door to the containers. The Department had totally about 30 trucks for door-to-door collection, 48 lifter trucks, and 10 compactors, which collect from the 1.1m³ containers. These trucks are not adequate to collect and transport the solid wastes produced in the city. The frequent damage and extended dead time of the trucks have made the problem more worse, as a result, the containers are not picked-up on time, before they have been full over and solid wastes are piled high at the container sites. Moreover, the door-to-door collecting trucks did not meet the beneficiaries at an accessible streets and roads and at a definite time. In other words, on the one hand, the beneficiaries did travel longer distances to empty their receptacles into the trucks. On the other hand the door-to-door collecting trucks had no well-defined schedule that consists of collection route and timetable.

The study also shows that the quantity of solid waste collected and disposed off to the final disposal site (Repi landfill) had generally increased annually since 1984 E.C, with a little fluctuation (See Appendix B). It was estimated that about 263,126,000 kg of solid waste was generated in 1993 E.C. However, though it has been calculated (and the SWMD estimated) that about 60-65% of the solid waste generated in the city in 1993 Fiscal year (has been collected and disposed off, it is argued that the actual coverage has to be far below this for various reasons. Firstly, the solid waste produced in the city has to be well over what has been

estimated by the Department because the rate of generation (0.267 kg/capital/day) used by is too low to be valid currently. Secondly, what has been practically observed in the city about solid waste management hardly matches with what has been claimed or calculated, i.e. 60-65%. Therefore, it has been argued in the study that much larger portion of the solid waste produced in 1993 Fiscal year has been left uncollected in the city.

As far as the role of the residents of Addis Ababa is concerned, it was noted that the communities' bad solid waste management practice (improper handling and improperly placing of their wastes into the container) aggravated the problem of solid waste in the city. Moreover, whether due to negligence, lack of awareness or shortage of services, the community dumps its wastes anywhere illegally in the city.

CHAPTER THREE

THE CHARACTERISTICS OF DOMESTIC SOLID WASTE IN MEKELLE

Any activity connected with management of solid waste primarily depends on the characteristics of the solid wastes generated. It is based on the knowledge of the nature of the solid waste generated that city administration determine the types and quantities of solid waste storage containers needed, the types and quantities of collection and transportation equipments and the types and capacity of the disposal sites required. Fortunately, the manager will be able to even determine the manpower size and amount of budget required to run satisfactory solid waste management service.

The characteristics of solid waste refer to the many aspects of the solid waste: the composition (constituents), the rate of generation, the biodegradability, the moisture content, etc. of the solid waste. However, the composition and generation rate of solid waste are by far more important aspects that need due attention in the activities of solid waste management. In fact, for more efficient and economic operation of solid waste management, the manager/administrator requires not only information about the characteristics of the solid wastes produced in the respective urban area, but she/he also needs to know the source of the solid wastes including the proportions of each source and the factors that affect the characteristics of solid wastes produced in the respective urban area. All these are the preliminary activities in any solid waste management system.

3.1 The Constituents (composition) of Domestic Solid Wastes in Mekelle

The composition (both physical and chemical) of the domestic solid wastes of Mekelle will help particularly to determine the types of storage containers, the frequency of collection, recovery and processing techniques, and disposal options. However, despite all this importance, the Health Office of Mekelle, which is currently responsible to run the solid waste management service in the city, has hardly made any attempt to identify the types of

constituents (the composition) of the domestic solid wastes generated in the city; moreover, the writer has never come across a research work conducted on this area in Mekelle.

Obviously, it is beyond the scope of this study to identify each and every individual item that constitutes the domestic solid waste generated in Mekelle. Nevertheless, through thorough observation, the writer has tried to identify the items that predominantly constitute the domestic solid wastes of Mekelle. Items like ash, food items, and grasses and leaves constitute the largest proportion of the domestic solid wastes at least in volume. The proportion of plastic materials like plastic bags, and paper is also considerable. Usually fine soil particles are not kept into the receptacles at home to be emptied into the containers. But they are spread around. And this shows that the characteristics of the (domestic) solid wastes of Mekelle, with respect to composition, is similar to that of the cities of developing countries, where putrescible items like garbage constitute the largest proportion.

The responses of the sample households, with respect to the proportion of the individual items of the solid wastes they produced, are not different from my observation. About 60% of the respondents have put ash, food items and grasses and leaves within 1 to 3 rank orders. On the other hand, plastic and rubber, and papers are ranked 5th and 6th by about 51% of the sample households. Metals and glasses are not only least in rank but also not reported by most households. Thus it seems that these items are proportionally insignificant.

3.2 The Rate of Domestic Solid Waste Generation

As it has been noted earlier, the rate of generation is invaluable information for any activity of solid waste management. The quantity of storage containers, the collection frequency or the quantity of collection vehicles, and the capacity of disposal site, the workforce size, and amount of budget required in a particular urban area are mainly the function of the rate of generation of solid wastes of the respective urban area. Yet, the

responsible body has not conducted a survey to estimate the quantity of solid waste produced in Mekelle. But the Health Office, sanitation section, applies the constant 0.3kg/capita/day to estimate the quantity of solid wastes generated in the city. This means is that each and every resident in Mekelle produces 0.3kg of solid waste within a day. Based on this generation rate, it would be possible to estimate the total quantity of solid waste generated in Mekelle with in a day as well as a year. Accordingly, in 2001 (1993/94 E.C) it was estimated that about 39792.9 kg of solid waste was generated in a day and about 14524408.5kg of solid waste in a year in Mekelle. This includes all types of solid waste generated in the city such as domestic, commercial, industrial and the like. Even though, a survey has not been conducted as yet on the proportion of each source of solid waste in Mekelle, it would not be much different from the case of the urban areas of other developing countries including Addis Ababa. Domestic solid wastes constitute the highest proportion of solid wastes produced in urban areas. For instance, in Addis Ababa domestic solid waste accounts for about 75% of the solid wastes produced in the city. (Source: document of the SWM Department of Addis Ababa).

In the case of Mekelle, the proportion of domestic solid wastes would not be less than that of Addis Ababa for Mekelle has limited number of industries and commercial enterprises. Then if we apply the ratio of domestic solid wastes of Addis Ababa (i.e. 75%) to Mekelle, about 10893306.38 kg of solid waste was generated from residential areas in Mekelle in the year 2001.

The spatial pattern of the domestic solid waste generated shows that there is a significant variation among the Tabias (see Table 3). Tabia Adi Haki alone accounts for about 9.9% of the domestic solid wastes produced in the city, while Tabia Hayet generates the least quantity of domestic solid waste, which accounts for only about 2.2%. Generally, domestic solid waste produced in very few Tabias constitutes the largest proportion of the city's

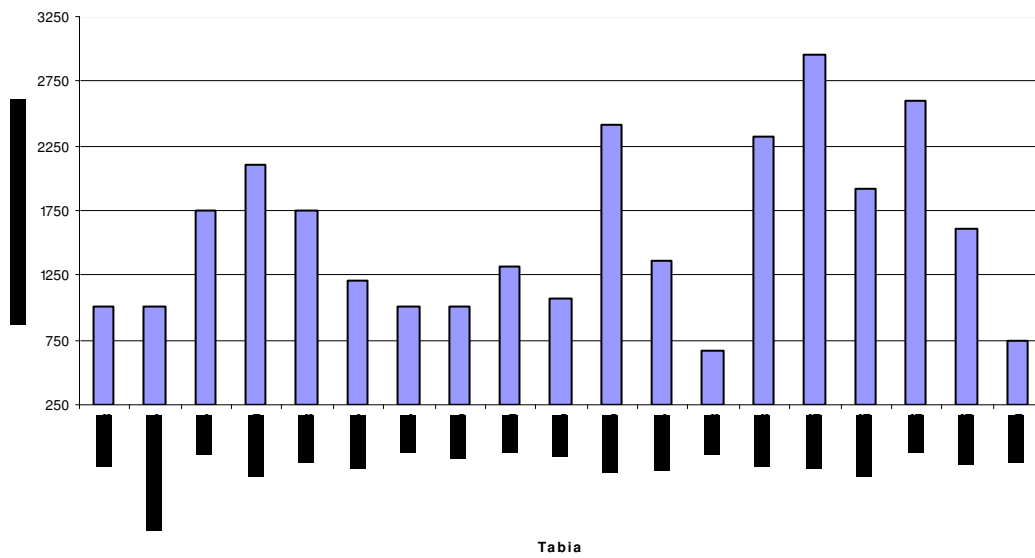
domestic solid waste. For instance, 5 Tabias (Adi Haki, Worei, Hayelom, Hadnet, and Ginbot 20) together produce about 41.6% of the total domestic solid wastes of the city.

Table 3. The daily and yearly distribution of domestic solid waste generated by Tabia, 2001

Tabia	Total quantity of D.S.W generated in a day (kg)	Total quantity of D.S.W generated in a year (kg)	Percentage of D.S generated
1. Dedebeit	1011.73	369281.45	3.39
2. Kedamay Woyane	1014.72	370372.80	3.40
3. Sertse	1742.93	636169.45	5.84
4. Genbot 20	2104.05	767978.25	7.05
5. Yekatit	1742.93	636169.49	5.84
6. Industry	1214.68	443358.20	4.07
7. Alene	1005.77	367106.05	3.37
8. Mesfine	1011.73	369281.45	3.39
9. Walta	1322.12	482573.80	4.43
10. Selam	1062.47	387801.55	3.56
11. Hayelom	2414.43	881266.95	8.09
12. Zesilasie	13.60.92	496735.80	4.56
13. Hayet	665.54	242922.10	2.23
14. Hadnet	2327.89	849679.85	7.80
15. Adi Haki	2954.62	107843630	9.90
16. Adi Hawsi	1916.03	699350.95	6.42
17. Worei	2602.46	949897.90	8.72
18. Hawelti	1611.61	588237.65	5.40
19. Hareya	752.09	274512.85	2.52
Total	29844.68	10893308.20	99.98

A sample survey on household's solid waste generation rate has been done. The findings of the survey are shown in Table 4. This survey was primarily carried out to examine the pattern of domestic solid waste generation with respect to the socio-economic characteristics of the households. The assumption is that higher income groups live in relatively higher quality houses, and vise-versa.

Fig.1 Daily Domestic Solid Waste Generation Rate By Tabia, 2001



After the sample households have been categorized into three income groups, each household was happened to collect his/her solid waste individually in the receptacles provided by the researcher for seven days successively. Then the researcher collected the receptacles from each household and weighing them using the large balance. The details are shown in table 4.

Fig. 2 Assistants Weighing Domestic Solid Waste



The solid waste generation rates of the relatively higher income house holds lie between 0.168kg/capita/day and 0.494kg/capita/day. The solid waste generation rate of the lower income households varies between 0.134kg/captia/day and 0.375/capita/day. And the households that lie between these two income groups have a generation rates that range form 0.25kg/capita/day to 0.4kg/capital/day. The average generation rates of the sub-groups, the higher income, middle-income and lower-income-groups are 0.412kg/cap/day, 0.301kg/cap/day, and 0.277kg/capital/day. This clearly shows that solid wastes generation rate varies significantly with socio-economic condition, particularly economic status of the households. The higher income groups generate relatively lager quantities of solid waste than the lower income households.

Table 4. Domestic solid waste generation rate by income-level

Income Group	Identification Of sample unit	Family size	Total quantity of D. solid waste generated in a week(kg)	Gen. rate kg/cap/ day	Gen. Rate Kg/cap day
Higher	H.H1	11	45	4.090	0.584

	H.H2	10	23.5	2.350	0.335
	H.H3	14	55	3.928	0.561
	H.H4	10	30	3.0	0.428
	H.H5	10	17	1.7	0.242
	H.H6	8	13.5	1.687	0.241
	H.H7	12	46	3.833	0.547
	H.H8	15	54	3.60	0.514
	H.H9	11	13	1.181	0.168
	H.H10	6	21	3.5	0.5
	Sub-Total	105	318	2.972	0.412
Middle	MH1	5	14	2.8	0.4
	MH2	5	13	2.6	0.371
	MH3	5	11	2.2	0.314
	MH4	6	10.5	1.75	0.25
	MH5*	4	45.5	11.375	1.625
	MH6	5	9.5	1.9	0.271
	MH7	9	17	1.897	0.271
	MH8	6	10.5	1.75	0.238
	MH9	6	14.5	2.46	0.345
	MH10	6	12	2.0	0.285
	Sub-Total	53	112	2.113	0.301
Lower	LH1	1	2.5	2.50	0.357
	LH2	4	7.5	1.875	0.268
	LH3	6	11.5	1.917	0.274
	LH4	9	16.5	1.50	0.214
	LH5	6	11	1.833	0.261
	LH6	7	13	1.857	0.265
	LH7 *	3	26.5	8.833	1.26
	LH8	3	6.5	2.167	0.309
	LH9	4	9	2.250	0.321
	LH10	2	4	2.00	0.286
	Sub-Total	42	81.5	1.94	0.277

* Not included in the calculation of the sub total

HH = Higher Income Households

MH= Middle Income Households

LH= Lower Income Households

Another important purpose of the measurement of solid waste produced by sample households is to roughly estimate the total average generation rate of households. It is true that the total number of households that can be designated as higher-middle-and lower-income groups vary markedly. Obviously the number of the higher-groups is by far lower than the rest two groups. So, the relative proportion of each income groups has to be used to calculate the

average domestic solid waste generation rate. However, data indicating the relative proportion of each of these groups is not available.

Income groups	Av. Gen. Rate of a group (kg/cap/day)
Higher	0.412
Middle	0.301
Lower	0.277

Very surprisingly the survey results of two households (one from the middle income and the other from the lower income groups, designated as MH5 and LH 7 respectively) have been extremely high. The main reason, as I have been informed from the respective households, is that they were having some form of cultural ceremony. Fortunately, this may be good instance that clearly shows how solid waste generation rate is affected by the culture of the society. Therefore, because of the different cultural practices accompanied by meal (ceremonial invitations), prevailing in Ethiopia, the quantity of solid waste produced is likely to be inflated. In deed, these two households have been excluded from any types of calculations.

CHAPTER FOUR

THE STORAGE, COLLECTION AND TRANSPORTATION, AND DISPOSAL OF DOMESTIC SOLID WASTE IN MEKELLE

The provision of storage containers, collection and transportation and disposal of solid waste is the main function of the solid waste management service. The Mekelle solid waste management service is primarily responsible to provide efficient and adequate container services, collection and transportation services, and disposal site services (i.e to prepare and

make use of controlled disposal sites). All these responsibilities lie mainly upon the Health Office of the Special Zone of Mekelle. Unfortunately, there is no private enterprise or NGO involved either in providing container service, collection and transportation service or disposal site service.

As it has been clear from the sub-title, the solid waste management service provided in Mekelle can be broadly classified into three: The container service, the collection and transportation service, and disposal site service. As noted in the previous section, any activity associated with all these services primarily depends upon the characteristic of the solid wastes, particularly the quantity of solid waste, produced in Mekelle. But each of these services also depends upon one another. If one service is affected, for instance weakened, the others will also be affected. This is what is called system continuity. On the other hand, if one of these services is poor it is not possible to claim that a satisfactory solid waste management is provided even if the other two services are good. It is very difficult to bring satisfactory solid waste management service to the city as a whole without adequate services of each of these service phases. Therefore, for adequate solid waste management service, each of these services has to be satisfactory.

4.1 On-Site Storage Containers

This refers to the secondary storage containers. Unlike to the primary storages (usually called receptacles), which are privately owned by the residents and are of diverse types and nature, secondary storage containers used in Mekelle are owned by the public and are usually of large size and standardized. The Health Office, Sanitation Section, has made 20 containers to be used in the city since the second half of the 1992 E.C. The Mesfin Industrial Engineering locally makes all of these containers. Their design is more or less similar to that of Addis

Ababa's 8m³ containers. The holding capacity of each container, as indicated by the specification order, is 8.4m³ volume. It has no lid, it is open-top. However, practically the optimum capacity of the containers, as Ato Kinfe, the Head of the Sanitation Section of Mekelle has noted, is believed to be 8m³.

So it is believed that the 20 containers in the city can hold about 160m³ (59200kg) of solid waste at a time. Note that according to the Addis Ababa Solid Waste Management Department, 1m³ solid waste is 370 kg by weight. Therefore, all the containers can accommodate the solid waste generated in Mekelle in less than a day and half provided that in 24 hrs (one day) about 39792.9 kg of solid waste is estimated to be generated. Thus, had the tractor collection service not been there, every container would have been picked-up in every one and half a day. In fact, if 2 tractors are working smoothly for the whole day to collect 4440 kg of waste, there is about 35352.9 kg of solid waste left that otherwise would be accumulated into the containers daily in the working days. This will occupy about 59.72% of the volume of all containers. This implies that all the containers will be full with in almost less than two working days; where as in the non-working days, when there is no collection service, about 67.22% of the containers will be full daily. In other words, in the working day (where 2 tractors are working full day to collect 6m³ each) about 12 containers would be full in a day; and in the non-working day nearly 14 containers become full daily to be collected. This implies that for Saturday and Sunday (non-working days) over 28 containers are needed.

The distribution of the storage containers within an urban area is an important issue that needs a serious attention. Facilities in general, containers in particular have to be distributed in such a way that they conform to the distribution of population (and thus rate of solid waste generation) and the optimum travel distance of the beneficiaries is secured. Therefore, Areas of larger number of population (and larger quantities of solid waste

production) deserve large number of containers unless there are certain mechanisms of adjustment (or compensation).

Currently, the 20 storage containers are found distributed among 15 Tabias. The four Tabias that have no containers are being served by the door-to-door collecting tractor-carriages. In fact, the tractors are also serving some other Tabias that have storage containers. The distribution of facilities mainly storage containers among Tabias indicated in Table 5 based on the assumption that a container located in a specific Tabia is meant to serve merely the respective Tabia's population. However, it is not unusual to identify containers located along the boundary of two Tabia or are nearer to the residents of the neighboring Tabia than to most of the residents of the Tabia where the container is sited on. For instance, as it can be seen in Map 5, the container sited at DD1, DD2, MS1, and HW1 are almost located on or near to the boundary line between Tabia Dedebit and Kedamay Woyane, Tabia Dedebit and Sertse, Tabia Mesfin and Alene and Tabia Hawelti and Herya respectively. So it may not be fair to assume that the containers are sited to serve merely the residents of the Tabia where the respective container is sited on.

Health Office Sanitation Section claims that it has tried to distribute and to site containers, in consideration to the public demands, in collaboration with the public administrators-both the Tabia and Woreda leaders. Thus, the Office argues that the containers are sited in relatively suitable open-areas.

Table 5 Allocation of facilities by Tabia,

S.No	Tabia	Container	Tractor*	Total	S.No	Tabia	container	Tractor*	Total
1.	Dedebit	2	-	2	11	Hayelom	2	-	2
2.	Kedamay woyane	1	1	2	12	Zesilasie	2	1	3
3.	Sertse	1	1	2	13	Hayet	-	1	1
4.	Gnbot 20	-	1	1	14	Hadnet	2	1	3
5.	Yekatit	-	1	1	15	Adi Haki	-	1	1

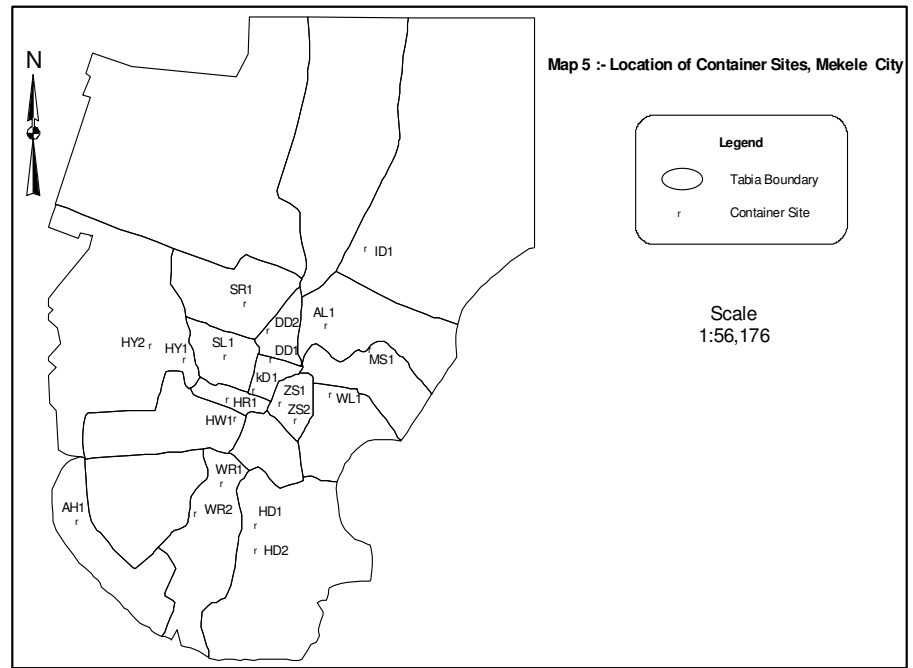
6.	Industry	1	-	1	16	Adi Hawsi	1	1	2
7.	Alene	1	1	2	17	Worei	2	1	3
8.	Mesfine	1	1	2	18	Hawelti	1	1	2
9.	Walta	1	-	1	19	Hareya	1	1	2
10	Selam	1	1	2					
	Sub total	9	7	16			11	8	19
	Grand Total						20	15	35

*One-tractor-service day in a week

Source: Health Office, Sanitation Section

The distribution of the containers including tractor services among the Tabia as well as on space is not uniform and even containers and tractor services are not distributed uniformly, and equally among Tabia and evenly on space. Some Tabias have more facilities than others. Three Tabias, for instance, have 2 containers and one-day tractor-service per a week each. These include Tabia Zeslasie, Hadnet and Worei. In contrast, there are Tabias, which receive merely one-day tractor service per week, such as Tabia Hayet, Tabia Ginbot 20, Tabia Yekatit and Tabia Adi Haki.

The distribution of the containers in the city is not spatially even and the containers are sited widely apart. As it can be seen in Map 5, there are very wide areas within the city which are very far from the containers. In other words, the containers are very distant to many of the residents of the city. Most of the residents in the outer part of the city are particularly very far from the containers.



The Abbreviations Used for the Container Sites

Tabia	Abbreviation
Sertse	SR1
Dedebit	DD1 and DD2
Industry	ID1
Alene	AL1
Mesfin	MS1
Walta	WL1
Zesilasie	ZS1 and ZS2
Selam	SL1
Worei	WR1 and WR2
Hadnet	HD1 and HD2
Adi Hawsi	AH1
Hayelom	HY1 and HY2
Hawelti	HW1
Hareya	HR1
Kedamay Woyane	KW1

In addition to the large containers distributed in the city, the Health Office has recently introduced dustbins. Formerly there were about 60 dustbins installed on the side of the main (Asphalted) streets in the city. But now four of them have been out of use because of damage. The dustbins are essentially to collect very light, of little volume pieces of solid wastes like napkins, paper, cigarette butts, etc used by pedestrians.

4.2 Solid Waste Collection and Transportation Service in Mekelle

The solid waste collection and transportation system currently operating in Mekelle started towards the end of the 1992 E.C Two types of collection systems are functioning: the container system specifically the Hauled-containers System, and the Door-to-Door Collection System. The Health Office-Sanitation Section runs the hauled container system, through two skip-loaders introduced to Mekelle in the second half of the year 1992 E.C. The function of these vehicles is to pick-up /collect and transport the containers distributed throughout the city and empties them at the final disposal sites.

Currently the Door-to-Door solid waste collection service is provided in Mekelle through tractor-carriages which have been introduced in the 2nd half of the 1992 E.C.. In fact, before the advent of the tractors, the door-to-door collection was provided through trucks. These tractors were originally the property of the SART (Sustainable Agriculture and Rehabilitation of Tigray), non-governmental organization. But when the tractors came in the second half of 1992 E.C to help the cleanliness campaign, they remained as the property of the Health Office to give a regular solid waste collection service in the city. Originally the number of the tractors involved in solid waste collection was four, but later their number has been decreasing due to damage. Without considering the temporary on-off duties due to damage, for so many months there have been only two tractors. Unfortunately, one of the tractors has recently seriously damaged and has been out of function.

Operational system of the solid waste collection and transportation fleet

According to the explanation of the Head of the Sanitation Section, the tractors serve areas (Tabias) not covered by the Hauled-container system; that is Tabias (areas) that have no container around, and congested Tabias (areas) that have shortage of containers. Currently, the programme of the Health Office shows that the three tractors are assumed to cover fifteen Tabias, of which four Tabias have no container at all (See Table 6).

Table 6. Daily programme of the Tractors' service by Tabia

	Days				
	Monday	Tuesday	Wednesday	Thursday	Friday
Tabia	Adi Haki	Adi Hawsi	Worei	Hawelti	Hadnet
	Ginbot 20	Yekatit	Kedamay Woyane	Selam	Sertse
	Hayet	Maebel/Zesilasie	Hareya	Alene	Mesfin

Source: Health Office, Sanitation Section, of Mekelle

Each tractor has five normal working days in a week (i.e Monday-Friday), and one tractor is serving five Tabias. Each of the fifteen Tabias is assumed to get one tractor-service day in a week. The Head of the Sanitation Section noted that whenever programme disruption occurs, his Office arranges a programme in the non- working days (Saturday and Sunday) to make-up for the expired programme.

One tractor is able to collect and transport, and empty its content to final disposal site twice a day, one in the morning and one in the afternoon. Note that for a single one round trip from the city to the disposal site, the tractors take them 3 hours. The Office believes that though the tractors can carry 4m³ solid waste each at a time, large part of the solid waste is exposed to falling and is lost before it reaches the final disposal site. Nevertheless, the tractors carry their optimum capacity that is 3m³ each at a time. Therefore, it is only 6 m³ of solid waste that can be collected from a Tabia in a week using tractor-carriages.

On the other hand, the skip-loaders pick-up the containers-one container each at a time. The Head of the Sanitation Section noted that container is assumed to be ready to be picked-up only if it holds its maximum capacity, i.e. 8m³, because since the final disposal site is very distant, it does not pay to pick-up a container that is not full to its maximum capacity. But here, a number of questions can be raised; does the Health Office regularly follow the condition of the containers? What are the mechanisms by which the Health Office acquires information about the containers that need collection? And does the Health Office respond as soon as it is informed? The Health Office claims that it uses a number of sources of information: from its workers assigned as Sanitary Guards at Tabia, the Tabia or Woreda leaders, and from any concerned employees (workers) of the Health Office of Mekelle. Moreover, the drivers of the skip-loaders themselves usually go out to patrol. However, despite the claims of the Health Office Sanitation Section that it uses multi-informants, most of the containers are usually collected (picked-up) after they have been filling beyond capacity and waste piled up on the ground.

The operational level of solid waste collection and transportation service

Indeed, the operational (performance) level of any agent of solid waste collection and transportation service provision is a function of many variables such as the number of collection vehicles, collection frequency, the capacity of the vehicles to hold (collect) solid wastes at a time (holding capacity of vehicles), the manpower size, the budget size, and the organizational system of the service providing agency. Then, having all these aspects in mind, how much solid waste is collected by the Health Office or/and by other alternatives.

Formally, solid wastes are collected, transported, and disposed off by Health Office. Though it would have been good had there been a data of more years, it is possible to make a fair analysis and reach at conclusion regarding the performance of the Health Office.

Table 7. Total quantity of solid waste formally collected and transported by the Health Office, by collection system and month, 2001

Month	Qnt. Solid waste collected, by Vehicles*		Total Qnt. Of Solid waste collected	
	Skip loader (kg)	Tractors (kg)	Qut. (Kg)	Coverage (%)
January	417,360	148,740	566,100	46.77
February	102,560	149,850	552,410	45.64
March	290,080	123,210	413,290	34.15
April	337,440	156,510	493,950	40.81
May	372,960	120,990	493,950	40.81
June	358,160	95,460	453,620	37.48
July	322,640	41,070	363,710	30.05
August	390,720	-	390,720	32.28
September	417,360	-	417,360	34.48
October	408,480	113,220	419,800	34.68
November	352,240	269,360	621,600	51.36
December	346,320	84,360	430,680	35.58
Total	4,416,320	1,302,770	5,719,090	39.38

* Source: Health Office-Sanitation Section

As it can be seen in the table 7, in the year 2001, the Health Office has collected about 5,719,090 kg (15,457m³) of solid waste. To collect and dispose off this quantity of solid waste from the city, both the skip-loaders and tractors have made totally 1492 and 1022 round trips respectively. In fact, the number of tractors involved varied considerably. For, instance during the first three months of the year, four tractors were involved every month. To the contrary, in August and September, all the tractors were off-duty as they were all being serviced. In July one tractor alone was on-duty (was functioning). Where as for most of the rest months only two tractors were functioning.

The total quantity of solid waste collected and transported to final disposal site by the skip-loaders is extremely larger than by the tractors. The skip-loaders alone performed about 77.2% of the solid waste collected in the year 2001; where as the solid waste collected in the same year by the tractors accounted for about 22.8% of the total solid waste collected.

When the quantity of solid waste formally collected and disposed off to the final disposal site is compared to the quantity of solid waste estimated to be produced in the city in the same year, it is extremely lower. Of the total quantity of solid waste produced in the year 2001, 14524408.5kg, it was only about 39.38% that was collected and transported formally, more or less properly, to the final disposal site. This implies that about 60.62% of the solid waste produced in the year 2001 was left uncollected.

The monthly report of the year 2001 of solid wastes collection and transportation service shows that there was very large fluctuation in the performance level of the Health Office. Assuming that the same quantity of solid wastes were generated at each and every month in the year 2001, the monthly solid waste collection and transportation coverage through

formal service by the Health Office-Sanitation Section, is shown in Table 7. As this table shows, the monthly solid waste management service coverage through formal means ranges between 30.05% in July and 51.36% in November. In other words, in July the coverage was 9.33% less from the annual average coverage, and in November coverage was 11.98% over the annual coverage of the Office.

In addition to the formal collection and transportation service run regularly by the Health Office, there is a tradition of conducting public cleanliness-campaign service long time ago. The campaign programmes involve the residents of Mekelle. The programmes can be

distinguished into two. One is more or less regular which is conducted for a day at every second month. During this programme, every resident is happened to be coordinated under its respective Tabia and comes out together at a fixed date. Usually the residents clean their Tabia and nearby (neighboring), severely affected, areas.

In fact, this programme has multipurpose. For instance, in addition to cleaning their Tabia from solid or other types of wastes, the residents level-off water-holding depressed ground that could be favorable area for mosquito multiplication. Usually, the solid wastes collected during this programme are put into either the nearby container or into the tractor-carriage. And sometimes it is burnt off. However, the residents noted that a large quantity of solid wastes collected by the residents during the campaign program are left uncollected and are seen piled everywhere in the city.

The second cleanliness campaign is conducted occasionally in commemoration of certain celebrations and holidays like Yekatit 11, and Ginbot 20. This type of cleanliness campaign programme may be different from the first one in that sometimes certain private as well as government vehicles (Trucks) are mobilized during this programme. Unfortunately, it has been too difficult to quantify the performance of the cleanliness campaign programmes with respect to solid waste management. Data on the estimated quantity of solid wastes removed of through public campaign programmes is not available. But verbally the public administrators as well as the Health Office, Sanitation Section, reported that the cleanliness-campaign contributed significantly to solid waste management in the city.

Processing and Recovery of Solid waste

The processing and recovery of solid waste has multi significances: It increases the efficiency of the solid waste collection and disposal service for it reduces the potential size of solid wastes and thereby savings in costs of solid waste collection and transportation can be

achieved; it increases the conversion of solid wastes into usable (salvageable) items and ultimately the exploitation of natural resources could be reduced; and it would be the main sources of earnings of the individuals involved in informal activities. However, despite the enormous benefits achieved from the processing and recovery of solid wastes, there has no any attempt to practice it.

For instance, the role of the informal activity, the rag pickers or scavengers or the like in solid waste management is undoubtedly significant. Besides its economic value, it can increase the efficiency of the solid waste management service for it is able to reduce the quantity of solid waste that otherwise would have been collected and disposed off to the disposal sites by the government.

Very surprisingly, the responsible body i.e. the Health Offices-Sanitation Section, including its employees has no any appreciation of the role of this informal activity, particularly of the scavengers and rage pickers in the solid waste management. So the Office does not allow them to search, scavenge and collect usable (Salvageable) materials form the containers. In fact, a significant number of scavengers are visiting the disposal site.

The so-called Liwach may be one of the most important informal activities that have great significance in solid waste management. It is well known that Liwach has been in practice for so long time in Ethiopia particularly among the people of Tigray.

Fig 4. Reg-picker Carrying his Sacks in the Disposal Site



Of course, Liwach seems that it has been almost an official informal activity in the city. Even the residents are well aware of the importance of Liwach. Metallic materials or glasses are rarely thrown away anywhere. Many people have a well-developed tradition not only to exchange or sell certain used items but also to convert them into another utilities by handcrafts, particularly metallic materials. However, the same as to the cleanliness campaign, it has been difficult to estimate how much of the material that would have been disposed off have been diverted to Liwach.

Collection Frequency

This refers to the rate at which collection vehicles have made trips within a specific time, and the frequency at which containers are collected (picked-up). The former shows how efficient the collection vehicles are performing their duties. The later shows the importance of the site in terms of its centrality to service and indicates the risk of odor a particular container site may be exposed to.

The Health Office believes that the skip-loaders can make a maximum of five round trips within a day from Mekelle to the disposal site. This implies that four round trips can be taken for granted as an optimum number of trips for the skip-loaders. Having this in mind, it is possible to appraise the skip-loaders whether they are performing (their duties) above their capacity or below (as per to their capacity or not). Table 8 shows the number and types of vehicles involved in collection and transportation of solid wastes and average monthly and daily (of working days) number of trips per vehicle of the respective collection system. The highest number of trips per vehicles per working day of the skip-loaders is 3.2 performed in January and September, while the lowest is 2.2 trips/vehicle/working day in May. In other words, in January and September, one skip-loader has made three round trips daily for 18 working days and four round trips daily for four working days, and the other skip loader has made three round trips for seventeen working days and four round trips for five working days. Where as in May, each of the two skip loaders has made two round trips daily for seventeen working days and three trips daily for five working days.

On the average, in the year 2001, the skip-loaders have made 2.8 round trips each daily in working days. This implies that the skip-loaders, on the average have made less than three round trips daily in working days which is far below their optimum number of trips.

Table 8. Number of trips (or frequency of collection) per vehicles, 2001

Month	Vehicles involved*		Total no. of round trips*	No of trips/ per veh./ month	No. of trips/ veh./working day
	Type	No .			
Jan	Skip-loaders	2	141	70.5	3.2
	Tractor	4	134	33.5	1.5
Feb.	Skip-loaders	2	136	68	3.09
	Tractor	4	135	33.75	1.5
Ma.	Skip-loaders	2	98	49	2.2
	Tractor	4	111	27.75	1.26
Apr.	Skip-loaders	2	114	57	2.59
	Tractor	3	141	47	2.1

May.	Skip-loaders	2	126	63	2.86
	Tractor	3	109	36.33	1.65
Jun.	Skip-loaders	2	121	60.5	2.75
	Tractor	2	86	43	1.95
July	Skip-loaders	2	109	54.5	2.47
	Tractor	1	37	37	1.68
Aug	Skip-loaders	2	132	66	3
	Tractor	-	-	-	-
Sep.	Skip-loaders	2	141	70.5	3.2
	Tractor	-	-	-	-
Oct.	Skip-loaders	2	138	69	3.1
	Tractor	2	102	51	2.3
Nov.	Skip-loaders	2	119	59.5	2.7
	Tractor	2	91	45.5	2.06
Dec.	Skip-loaders	2	117	58.5	2.65
	Tractor	2	76	38	1.7
Total	Skip-loaders	24	1492	62.16	2.8
	Tractors	27	1022	37.85	1.7

*Source: Health Office, Sanitation Section

We know that the tractor's optimum number of round trips in a day, as to the Health Office's understanding, is two. But in practice the number of trips per working day per tractors has gone over the maximum number of tarps assumed (claimed) by the Health Office. In October, it has reached the highest number, that is 2.3 round trips/ tractor/ working day. Over 2trips/tractor/working day, possibly, implies that the tractor had conducted certain number of collection trips through over-time in non-working days (Saturday and Sunday.). For instance, 2.3 trips /tractor/working day, which is the highest of the year, could mean that about seven extra round trips have been performed through over-time, most likely on Saturday and Sunday. However, with the normal number of trips in a day, one tractor alone cannot make seven extra round trips within the two non-working days (Saturday and Sunday), unless and otherwise certain new mechanisms had been arranged/devised.

On the other hand, the lowest number of trips per tractor per working day has been recorded in January and February, that is 1.5 trips/tractor/ working day. This means is that a

tractor in the respective month has made almost two trips daily for about eleven working days and only one trip for eleven working days in a month.

On the average, the tractors have made only 1.7 trips per working day in the year 2001, excluding August and September during which there was no tractor service.

The frequency of collection of containers is given in Table 9. The number of pick-up (collection) per container per month and the number days per container shown in the table, are computed based on the data of six months (Meskerem-Yekatit). The frequency of collection of containers, as it can be seen in the table, varies widely. Some containers are picked-up more frequently than others. For instance the containers sited in Tabia Kedamay Woyane, the former market area, is the most frequently collected (picked-up) one. It is collected on almost every second day; even, sometimes it is collected daily. Where as the containers sited in Tabia Hayelom are collected least frequently, that is at almost every 26th day.

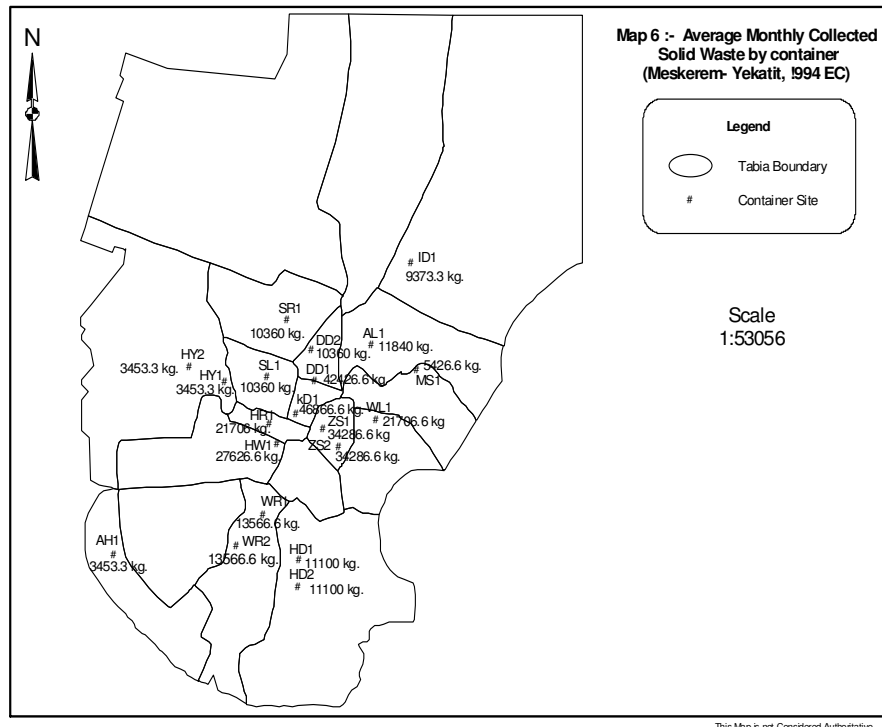
Table 9. Frequency of collection of containers with in six months, Meskerm-Yekaitit 1994 E.C

Tabia	Total no. of pick-up (collection)*	Freq. Of collection (no. of pick-up/month/cont.)	No. of days/contain er.
Sertse (SR1)	21	3.5	8.57
Dedebit: DD2	21	3.5	8.57
DD1	86	14.3	2.09
Industry (ID1)	19	3.16	9.47
Alene (AL1)	24	4	7.5
Mesfin (MS1)	11	1.8	16.36
Walta (WL1)	44	7.3	4.09
Zesilasie (ZS1 and ZS2)	139	11.98	2.58
Selam (SL1)	57	9.5	3.15
Worei (WR1 and WR2)	55	4.58	6.5
Hadnet (HD1 and HD2)	45	3.75	8
Adi Hawsi (AH1)	20	3.3	9
Hayelom (HY1 and HY2)	14	1.15	25.7
Hawelti (HW1)	56	9.3	3.2
Hareya (HR1)	44	7.3	4.09

Kedamay Woyane (KW1)	95	15.8	1.89
Total	751	125.166	

*Source: the Health Office, Sanitation Section

Generally almost 10 containers (which account for 50%) have been collected after 7 days, so they may create odor. In contrast, three containers have been collected with in less than three days, which implies that they are located at center to areas of higher rate of solid waste generation. In other words, the average monthly collected solid waste from KD1, and ZS1 and ZS2 containers is by far larger than the rest. From Meskerem to Yekatit 1994 E.C., about 42426.6 kg of solid waste from KD1, and about 34286.6kg of solid waste each from ZS1 and ZS2 containers have been collected (See Map 6).



4.3 Disposal of Domestic Solid Wastes

It is well known that the final fate of solid waste is disposal. Disposal site is the end point of all solid wastes of varied origin: domestic, commercial, industrial, solid waste processing facilities (commonly called residues), or the like. Therefore, disposal of solid wastes is an inevitable event in the solid waste management system. The question is how and where shall solid wastes be disposed off. Unless solid wastes are disposed off properly the provision of solid waste management service will be incomplete, whatever proper solid waste collection and transportation service is provided.

Currently, there is one disposal site at Messebo area, located 15 km north of Mekelle. The Messebo disposal site started function in Meskerem 1993 E.C. Disposal site was one of the severe problems of Mekelle according to the explanation of many officials including the Health Office. These officials remember how long and tiresome was the process to get a relatively adequate and long lasting disposal site-the Messebo area disposal site.

Primarily an Ad Hoc Committee was formed to identify and select disposal site. Representatives of different governmental and non-governmental offices formed this committee and organizations such as from the Offices of Agriculture, Water and Mineral, Urban Development, Health, SART and Messebo Sement Factory coordinated by the Municipality. Finally the committee selected a site somewhere at the Messebo area. In fact, initially there was a public opposition-from the peasants around, but latter it was settled when the responsible body agreed to pay them compensation.

But, unfortunately, the originally selected site was abandoned because of certain technical problems in construction and shifted to the present site which is about 400 meters west of it.

The disposal technique that is being used is an open dump. According to Ato Girmay, Expert of the Residential and Environmental Hygiene, Sanitation Section, every three months his Office orders the collection of the solid wastes to a very limited area and gets it compacted by a dozer rented from private organizations.

CHAPTER FIVE

MAJOR FACTORS CONSTRAINING THE SOLID WASTE MANAGEMENT IN MEKELLE

5.1 Introduction

It is not difficult to see from the forgoing discussion that the domestic solid wastes are poorly managed in Mekelle. The service is clearly inadequate. A very small proportion of the solid wastes produced in the city is, more or less properly, collected and transported (disposed off) to the final disposal site. It is only about 39.38% of the solid waste generated in the city as a whole that is formally collected and disposed off. In deed, though it has been difficult to figure out the quantity, or express it in terms of proportion, hopefully the public cleanliness-campaign programmes and the informal services have ameliorated the city's burden of solid waste considerably. However, undoubtedly, largest proportion of the domestic solid wastes produced in the city has been left uncollected and is seen littering the city.

The poor municipal solid waste management in Mekelle appeared to be largely a product of shortcomings of the responsible body, particularly the Health Office and the community of Mekelle. Both of them are equally responsible to the occurrence of solid waste management problem in the city. Both the residents as well as the workers of the solid waste management service giving body have admitted this fact. On the one hand, the Health Office has not been in a position to provide a satisfactory solid waste management service in many ways. On the other had, the community's practice and handling associated with domestic solid waste management has aggravated the problem of solid waste management in the city. Hence, for detailed identification of the problem, it would be advisable to classify the factors that constrain domestic solid waste management in Mekelle into two broad classes: Institutional and socio-cultural factors.

5.2 Institutional Factors

The institutional factors are the main factors that constrain the domestic solid waste management in the city. These include the organizational structure, manpower, facilities (Equipments); budget; rules and regulations; and solid waste disposal techniques.

5.2.1 Organization

Structure

The structure of the organization of the solid waste management in Mekelle is one of the problems of solid waste management service in the city. The solid waste management service in Mekelle has not the right structural organization that matches with the magnitude of its responsibility (and the degree of sensitivity and vastness of the problem). Usually solid waste management is organized under municipality, but in Mekelle it is within the Health Office. However, the problem is not only its being organized within the Health Office. But the structure of the organization of the solid waste management within the Health Office has also been part of the obstacles to provide adequate solid waste management services in the city.

From the very beginning, when the responsibility of solid waste management has been transferred to the Health Office of the Special Zone of Mekelle just after municipality system had dissolved (in 1990), there was no consensus between the Health Office and the higher administration officials. As to the explanation of certain officials of the Sanitation Section, it was by way of order that solid waste management transferred to the Health Office. But the Health Office has not yet been convinced to run solid waste management as its main duty. For most of the employees of the Office, solid waste management is considered as an extra duty. And this way of understanding of the office in general has greatly affected the solid

waste management service in the city in many ways. Primarily, the solid waste management service has not been given the necessary priority in the Health Office.

On the other hand, solid waste management service is very vast and seems beyond the capacity of the immediate bosses of the Section to run it and the other two services simultaneously. Moreover, solid waste management service could not get the necessary emphasis that it deserves, equivalent to the degree of its sensitivity and vastness.

Very surprisingly, the solid waste management system within the Health Office has not been organized even at a unit level. It is simply run under the Sanitation Section in combination with other two main services-liquid waste service and provision of license and supervision of food establishments. The solid waste management service is not well defined and developed vertically as well as horizontally. This implies on the one hand solid waste management service is not organized as a relatively autonomous body and this circumstance has exposed it for unnecessary bureaucratic processes. That is why the employees of the solid waste management including the bosses of the Section complain about the unnecessary delay for responses to their requests from the Office. For instance, the workers of the solid waste management argue that to fuel their vehicles (the skip-loaders and tractors) it usually takes them two and three days during which all the fleet are standing idle.

Manpower

As regards the manpower of the solid waste management service, aspects such as the organization, size, recruitment type, payment system are some of the most important factors that have influenced, the level and quality of operation (performance) of the solid waste management service.

The organization of the labour force of the solid waste management is not totally and directly under the Health Office, Sanitation Section. Large part of the manpower is organized under the public administration, -Tabia and Woreda, who account for about 75% the manpower size of the solid waste management in the city. Almost all the street sweepers, Container and River Course Guards, are totally within the direct administration of Tabia and Woreda. Where as the Sanitary Guards at each Tabia are largely under the respective Tabia and Woreda. It is only the drivers and their assistants of the skip-loaders and the tractors, and the officers including the supervisor are directly organized under the Health Office Sanitation Section. And this type of organization has come out with certain consequences. Though in principle, the manpower of solid waste management, whether it is under direct control and supervision of the Health Office or the Tabias and Woredas, works together for one and the same end, practically there is no coordination between the workers of both parties. For example, there is no formal means or way of information exchange or even understanding of one another between the Container Guards and the fleet dispatching body when the containers need collection.

As shown in Table 10, there are about 130 employees who are partly or fully involved in the provision of solid waste management service in Mekelle, of which about 25 workers (including the Sanitary Guards, the officers (Experts) and the supervisor), are responsible to run not only the solid waste management service, but also the other two duties (liquid waste service and provision of license and supervision of food establishments) of the Section. While the remaining 105 workers are merely concerned about and involved in the provision of solid waste management service in the city

Table 10 Manpower of the solid waste management in Mekelle by duty, recruitment, and payment type, 1994E.C

S.N.	Duty	Recruitment		Payment		Total
		Permanent	Temporary /contractual	In cash (Birr)	In kind (Wheat)	Total
1	Drivers	3	3	6	-	6
2	Assistants	2	-	2	-	2
3	Crew	-	4	-	4	4
4	Sanitary Guards	-	20	20	-	20
5	Street Sweeping	4	43	4	43	47
6	Container Guards	-	20	-	20	20
7	River Course Guards	-	26	-	26	26
8	Officers (Experts, heads)	4	-	4	-	4
9	Supervisor	1	-	1	-	1
	Total	14	116	37	93	130

*Source: The documents of Health Office, Sanitation Section and Tabia

Certain studies show that solid waste management services in cities of developing countries are labor intensive. For instance, the UNCH5 (Habitat) indicated that there are 3-6 workers per 1000 population. However, the number of workers of the Health Office involved in the provision of solid waste management service in Mekelle is extremely low. On the average there is only one worker per about 1020 population.

The payment system of the workers of the solid waste management is another problem area that greatly affects the working moral of the employees. About 71.2% of the labor force of solid waste management is paid in kind that is some wheat, monthly. The problem is not for mere reason that it is in kind, but there has no regular time when they are paid. For instance, all the 93 workers were not paid for the past two months, Tir and Yekatit and were really extremely up set. The issue that most of them were recruited not because they most qualify the job, but mainly to help them, worsen the problem of the respective workers and this has certain consequences. Firstly, the situation of their recruitment has prevented them from presenting an appeal dearly to the responsible body. Secondly, since most of them are so poor, the interruption or delay of payment has negatively affected their living conditions.

Obviously, the sources of the wheat that is given, as payment has been totally donation. Therefore, their payment totally depends upon the availability of adequate donation of wheat. This explicitly implies that the payment of the workers is liable to unreliability and irregularity.

But the workers argue that the problem is not only because their payment merely depends upon the availability of donation, which is irregular and unreliable, but also they complain that even if there is adequate donation (if wheat is enough in store) there is always delay in payment. Thus according to the workers, the problem is not totally related to the availability of wheat but there is also lack of concern by the responsible body (i.e their immediate bosses). Under these conditions, one hardly expect them to provide satisfactory solid waste management services to the community. Moreover, almost all, about 90.1% of the sample workers, believe that their payment is very low as compared to the vastness and hardness of the job. And about 68.2% of them argue that it has affected their working moral and devotion (See Appendix A -5).

The recruitment condition of the workers of the solid waste management of Mekelle shows that over 89% of them are contract or temporary workers. Most of the contract or temporary workers' service years lie between 5 and 15 years. The workers desperately say that they have presented an appeal to the responsible body so several times, yet they have not found any solution and as such are greatly dissatisfied.

About 63.5% of the sample workers of the solid waste management agreed that the recruitment type has been one of the many factors that eroded their working moral and devotion, and ultimately the scale and quality of the solid waste management service has been severely affected (See Appendix A -5).

The workers of the solid waste management do have some more complaints related to the responsible body as well as the community. The workers accuse the community because it does not have a healthy, positive attitude towards them and their job. Usually, they argue that most of the community underestimate or degrade the job, including its workers, of solid waste management and do not cooperate with them. About 72.7% of the respondents believe that the community has negative attitude towards the workers of the solid waste management and their job and does not make the necessary cooperation that is expected of them (See Appendix A-5).

The administration body has also been an important factor in affecting the moral of the worker in many ways. Many workers are heard expressing their problems as something associated with the administrative body of the Health Office. Some of the problems, as they express them, are bureaucratic process, lack of concern to their problems such as with respect to recruitment, payment, etc. About 86.36% of the sampled workers agreed that there has been a mal-administration in their office and this has greatly affected their moral to work and devote much (See Appendix A- 5).

The workers of the solid waste management service , particularly the River Course Guards and Container Guards accuses the Tabia's as well as the Health Office's officials because they don't cooperate with them. When ever violators are apprehended or are detected the responsible body does not penalize them.

Generally, the workers have believed that the working-moral and devotion of the workers has been killed by so many problems. These include the inadequate payment of the workers, which is not comparable to the hardness and vastness of the job; most workers, being temporary or contractual, lack guarantee in their work; the incompatibility of the number of

workers (manpower size) and the magnitude of the job; the community's being not co-operative with respect to solid waste management; and the mal-administration of their office.

Facilities (equipments) of solid waste management

Even though the solid waste management services in developing countries urban areas are labor-oriented, have large concentration of manpower, the importance of equipments(facilities) is very high. Equipments play a significant role, whether they are highly mechanized or not, in the activities of solid waste management..

We have seen that among the crucial equipments in any solid waste management, storage containers and collection vehicles are currently used in Mekelle. But the problem of solid waste management in the city is partly associated with the inadequacy and inappropriateness of the equipments and the improper system of operation of the equipments .

Storage Containers

From the point of view of management, the number, type, capacity (size), distribution, location /sitting (placement) of the containers in relation to the public health and aesthetic conditions of the city, and the ease to beneficiary to use are the main issues and concerns of the solid waste manager/administrator. Therefore, the responsible solid waste manager (body) of a particularly urban area, in order to provide a satisfactory solid waste management service to the respective area, has to give due attention to those aspects of on-site storage containers, and make necessary adjustments. However, when we see the case of Mekelle, most of the management issue (variables) of the on-site storage containers have not been thoroughly considered. Serious constraints are clearly observed in the quantities, distribution,

sitting/locating and types of the containers. And these have constrained the provision of solid waste management service in the city.

The number of the containers that have been in use are so few that it does not match with the area and population size of the city (i.e the quantities of solid wastes generated). The 20 containers can only hold the solid wastes generated in nearly one day in the city. And this implies that each and every container needs to be collected daily.

In fact, even though the tractors' services are irregular and unreliable (see it latter), certain quantity of the solid waste generated in the city is collected by tractors. However, even assuming that, on the average, there have been two tractors functioning fully daily, only 12m³ (4440 kg) solid wastes could have been collected by the tractors daily as the remaining solid waste, about 35352.9 kg could be put into the container daily. In other words, there will be about 35352.9kg solid waste produced daily left uncollected by the tractors to be placed into the containers during the working days. And this occupies over 59.72% of all the containers' holding capacity. This means that the solid waste generated in a working day which was left uncollected by the tractors (i.e 35352.9kg) will fill up about 12 containers. Where as during the non-working day (for Saturday and Sunday), when there is no regular/formal collection service, about 27 containers are needed to load all the solid wastes generated in the city in the two days.

Generally, all the containers will be full to their maximum capacity in less than one and half days provided that there are two tractors daily functioning normally. So every container needs collection twice in every three days including in the non-working days, and this may not be feasible under the existing condition of the solid waste management Agent, Health Office.

Therefore, the number of containers distributed in the city is so few they that are not able to accommodate the solid waste generated in the city for even two days (in a month).

On the other hand, due to shortage, containers are serving wider areas. As a result, residents (beneficiaries) are forced to travel longer distances to reach the containers to empty their receptacles.

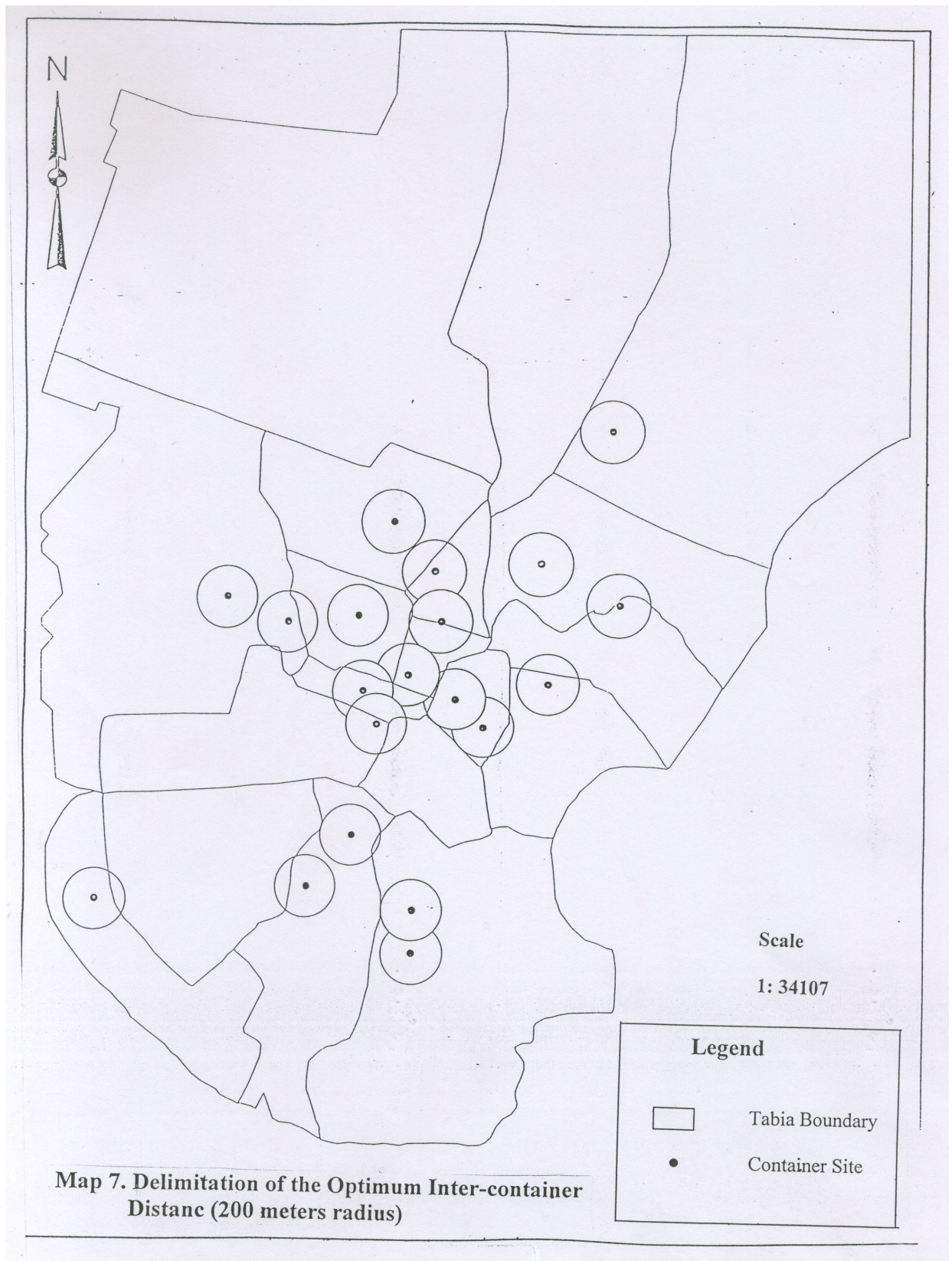
But beneficiaries may travel to get a container service only if it is a tolerable distance. Otherwise they will be forced to find other alternatives including dumping it anywhere illegally.

When the distance to the site of containers increases, the community may exhaust its tolerance to travel and reach such distant containers. Then as travel distance of the users (beneficiary) to the container sites increases unreasonably, the community's improper handling and managing of its solid wastes will be inevitable; wastes will be dumped (thrown away) everywhere within the city illegally.

Therefore, for proper solid waste management, it would be necessary to secure an optimum travel distance, that is the average distance the beneficiaries are expected to travel at ease to empty their receptacles into the storage containers. But the question is how long is the so-called optimum travel-distance of the users to solid waste containers. Of course, experts and scholars have tried to limit the optimum-travel-distance somewhere between 100 and 150 meters. The Nor consultant recommended 150 meters as an optimum travel distance of beneficiary. Whereas the United Nations Center for Human Settlement (Habitat) has indicated that the inter-containers distance (distance between containers) has not to exceed 200 meters. By implication the optimum-travel-distance has to be 100 meter, according to UNCHS. So as not to be over-ambitious it would have been advisable to examine the case of Mekelle against the optimum travel distance indicated by Nor Consultant, i.e 150 meters. However, it would

not be feasible to calculate the travel-distance on the ground of each and every resident to his/her nearby container. Therefore, I have tried to evaluate the case of Mekelle in terms of the distance indicated by UNCHS. In fact the UNCHS may have not made it clear whether the assumed inter-containers distance is a straight line (air-distance) distance or ground distance. And of course, because of the nature of the urban morphology, there could be a difference in length between the straight-line distance and the ground travel-distance. However it would be easier to apply and approximates much to that of the Nor consultant's optimum travel-distance i.e 150 meters, if the inter container distance limit of the UNCHS is assumed as straight-line distance.

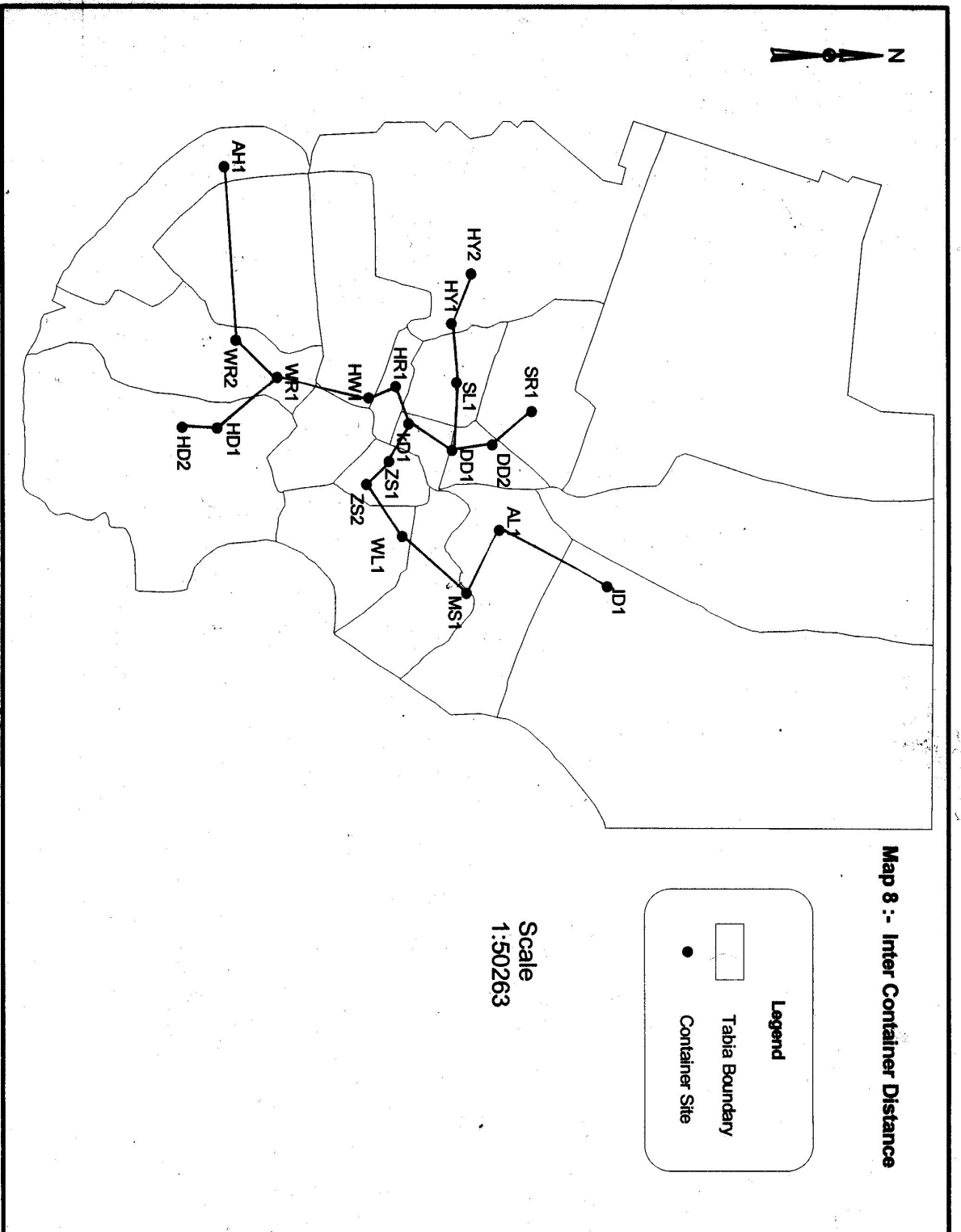
On the one hand, the delimitation of the required inter-container distance depicted in Map 7 shows that there were no containers located within 200 meters radius. Moreover, there were wider areas lying outside of the 200 meter radius from each container.



On the other hand, the straight line inter-container distance measured from the map can show us about the general feature of the existing container distribution in Mekelle. Then based on this assumption, starting from the outer most containers, each container is connected to the next nearest container by a straight line. And each straight-line distance, between containers, is measured assuming that the containers are sited at somehow in a linear pattern (See Map 8).

As shown in Map 8, the least inter container distance is that between HR1 and Hw1 which measured about 251 meters. This means that the inter-container distance of all the containers in Mekelle is beyond the limit recommended by UNCHS. The longest inter-container distance measured 1558 meters (1.558 kilometers), between WR2 and AH1 the average inter-container distance along a single route is 627 meters, over half-kilometer. This is about three times that of UNCHS's recommendation. This implies that the containers are sited/distributed far apart. In other words the residents of Mekelle travel extremely longer distance to reach the nearby containers and empty their receptacles. Consequently, the community has been forced to either dump its solid wastes anywhere in the city illegally such as in streets, river courses, etc. or to suffer much by traveling longer distances carrying wastes to the containers.

The very responses of the sample households with respect to the distance of the containers from their premises consolidate this fact. About 51.3% of the respondents agreed that the distance between their premises and the nearest container in general have a problem, where 71.9% of them said that the containers are too far to use (See Appendix A- 1).



The respondents have also tried to show the problem of distance by estimating the distance measured from their houses to their nearest container. About 49.3% of the sample householders estimated the distance as measuring over 200 meters. And in many cases it goes beyond half a kilometers.

In fact, the proportion of the respondents who have accepted the problem of distance, compared to the reality on the ground, is not satisfactory. This could be due to certain reasons. Firstly, most of the residents (householders) do not face this problem themselves because it is their children or house maids who usually take the responsibility to empty the solid wastes into the container. Of the total sample householders, it is only 31% who empty their receptacles to the containers themselves. Secondly, the severe problem of the container sites associated with its closeness to premises may have biased the respondents. Most of the residents whom I asked informally preferred to travel longer distances instead of having containers sited (placed) very near to their premises.

Undoubtedly, the travel distance of beneficiary is a function of many variables such as the quantity and the pattern of distribution of containers and the availability of adequate open-places for siting of the containers. When there are adequate number of containers as well as plenty of suitable spots to site them, the problem of travel-distance of beneficiaries can be greatly reduced.

The distribution of facilities within urban areas is one of the most important issues and concerns of the solid waste management that needs a serious attention. Logically, the distribution of facilities has to primarily conform to the population distribution pattern and to the rate of solid waste generation. Normally, areas (Tabias) of larger population (and thus larger rate of generation of solid wastes) require larger number of facilities and vice versa.

As far as the distribution pattern of facilities is concerned I would like to treat both the containers and the tractor-carriages simultaneously. This is because in many cases one has happened to substitute the other. Then the first main question regarding distribution of facilities is that “does the distribution of facilities among Tabias correspond to the size of population and volume of domestic solid waste generated in the respective Tabia?”

With regard to distribution of facilities, two main problems that constrain the domestic solid waste management are clearly observed in Mekelle. On the one hand, facilities are allocated to Tabia not based on the volume of domestic solid waste they generate. On the other hand there is a tendency for the concentration of facilities (containers) in the inner than the outer part of the city.

Based on the assumption that one container is better than a one day tractor-service in a week, I have tried to rank the Tabia according to the number (quantity) of their facilities (Table 11). The logic is that, from the point of view of capacity i.e. quantity of solid waste to be accommodated at a time, and reliability of service, one container is better than a single day's tractor service.

As shown in Table 11 Tabias are ranked according to their population size (and thus quantity of domestic solid wastes they produced) and the number of facilities assigned to them. Then a rank (Spearman's) correlation coefficient is computed as 0.08 at less than 10% significance level. Therefore, this implies that there is no meaningful relationship between population distribution and facility allocation among the Tabias. The facilities are distributed among Tabias irrespective of their population size and thus their domestic solid waste generation rate..

Table 11. Ranking of Tabias by number of population or quantity of domestic solid waste generated, and number of facilities

S. No	Tabia	Population size	Rank	Total number of facilities			Rank
				Container	Tractor	Total	
1	Dedebit	4503	15	2	-	2	4
2	Kedamay Woyane	4514	14	1	1-	2-	6
3	Sertse	7752	7	1	1-	2	6
4	Ginbot 20	9348	5	-	1-	1-	16
5	Yekatit	7748	8	-	1-	1-	16
6	Industry	5400	12	1	-	1	14
7	Alene	4476	17	1	1-	2-	6
8	Mesfin	4492	16	1	1-	2-	6
9	Walta	5882	11	1	-	1	14
10	Selam	4720	13	1	1-	2-	6
11	Hayelom	10727	3	2	-	2	4
12	Zesilasie	6053	10	2	1-	3-	1
13	Hayet	2964	19	-	1-	1-	16
14	Hadnet	10340	4	2	1-	3-	1
15	Adi Haki	13129	1	-	1-	1-	16
16	Adi Hawsi	8520	6	1	1-	2-	6
17	Worei	11567	2	2	1-	3-	1
18	Hawelti	7163	9	1	1-	2-	6
19	Hareya	3344	18	1	1-	2-	6

Another problem of distribution of containers is the disparity (Variation) between the inner and outer part of the city. As in the Map 8 the inner part of the city are relatively more favored than the outer part with respect to the number of containers they have. Most of the containers are found with in a relatively small area that may be considered as the inner part of the city. For instance, taking the container sited at the center of the previous market area (KD1) for granted as foci, about 50% of the containers in the city are found within about 1.005 km radius, that is, 50% of the containers are concentrated within 3.173sq.Km area of the city. The remaining largest area of the city is served by only 50% of the containers in the city and as one goes far from the center the container-service becomes increasingly scarce. This clearly

indicates the disparity between the inner and outer part of the city in container service where the inner part gets relatively better service at least with respect to securing optimum travel distances of the beneficiaries.

In deed, the Sanitation Section Head has admitted that his office has given more emphasis to the inner than to the outer parts of the city where the problem of solid waste management occurs relatively more severely. However, the office has not considered the travel-distance of the residents dwelling far away from the center.

As regards disparity in service most of the sample householders did not sense it. Relatively large number of respondents agreed that there was disparity in service between the inner and outer part of the city. About 41.97% of the 243 respondents believe that there is disparity in service provision between the outer and the inner part of the city. And about 77.3% of the sample workers of the solid waste management agree that there was disparity in service between the inner and the outer part of the city. About 94% of the same respondents believe that the inner part of the city is favored(See Appendix A-2 and 6).

The other disparity in service which has got relatively large number of acceptors is that between the residential areas and the business and office areas. About 34.7% of 230 respondents agreed that there is disparity between residential, and business and office areas. About 75.9% of these respondents reported that business and office areas are relatively more favored. About 63.3% of the sample workers also accepted that there is disparity, of which about 85.7% believed that the business and office areas are relatively better serviced.

The Sitting (or placement) of Containers

The placement /sitting of containers is also an important factor in the domestic solid waste management. The problem of sitting is usually more closely connected with the issues/problems of distribution of containers. In principle, containers have to be placed on

open space. But whenever we think of the placement of containers on open-areas, the question of spatially even distribution of the containers may be so difficult to fulfill due to the very nature of the morphology of the urban areas of developing countries including Mekelle. Each of these requirements may go against one another; one may be fulfilled at the expense of another. However there could be an ample opportunity to reconcile these requirements through thorough survey and research work and dedicated efforts of the responsible body.

The sitting of containers in Mekelle is among the very sensitive issues of solid waste management. The communities dwelling nearby the containers are strongly complaining and appealing to the responsible body persistently. And the Health Office, sanitation section, recognizes the severity of the problem of placement of containers. The Head of the sanitation section has claimed that his office has entertained so many public requests related with shifting of container sites-to take away from their premises. Accordingly, he noted, his office has shifted the sites of many containers so many times, but still the requests are coming.

Of course, it is true that the Health Office has done a lot in collaboration with the public administrators, particularly the Tabia leaders, with respect to sitting of containers on adequate open areas. I believe many containers have been currently sited on adequate open-areas for which no better alternative site may be found around, such as the containers placed on the market area of Tabia Hadnet (HD1), Tabia Kedamay Woyane (KW1), Tabia Hayelom (HY2) and Tabia Mesfin (MS1).

However, there are also containers placed very close to residential premises and near areas crossed by large number of pedestrians such as the containers in Tabia Zesilasie (both ZS1 and ZS2), Tabia Dedebit (DD1), Tabia Hawelti (HW1), Tabia Hareya (HR1), Tabia Industry (ID1), and Tabia Alene (AL1). The sites of the rest containers are not much better.

Generally, the response of the residents as well as the workers of the solid waste management service with respect to the problems of sitting (placement), distribution of containers and travel-distance of beneficiary to the containers has strengthened the idea explained above. About 53% of the respondents of the sample householders disagreed with the idea that the distribution and sitting (placement) of the containers in Mekelle have been carried out taking the distribution and density of the population, the availability of adequate open area, and the optimum travel-distance of beneficiaries into consideration.

The same is true as regards the responses of the workers of the solid waste management. About 71.4% of the sample workers, agreed that the distribution and sitting of containers has been done in Mekelle without taking into consideration the distribution and density of population and availability of adequate open-areas and the optimum travel distances of beneficiaries (See Appendix A- 1 and 6).

The unsanitary conditions of the containers and their sites in general and the bad odor that comes out of the waste in the containers has aggravated the sitting problem of the containers. The sanitation condition of the container sites in general has been spoiled due to various reasons, such as the community's mishandling of its solid waste at home and misuse of the containers such as improperly placing of waste into the container, and the unnecessary delay of collection for many days by the responsible body. Moreover, the Health Office has hardly made any effort to keep the containers and their site clean. For instance, there has no washing of containers, and no use of anti-odor, pests or the like.

The unsanitary condition of the container sites in general has not only damaged the public health and aesthetic condition of the city but also has aggravated the improper use of the containers by the public because the bad smell of the waste at the site has prevented the beneficiaries to come close to the containers and empty their receptacles into it properly.

The unsightly condition of the containers is also connected with the big-sized nature of the containers where huge, open piles of solid waste in the container creates unattractive condition.

The communities' complain about the bad odor created at the container sites is very strong. Almost all the residents whom I asked informally felt that it was a serious problem. Every one of them has told me that they rather prefer to travel unnecessarily longer distances carrying their receptacles to reach distant containers rather than having a containers sited very close to their home. When they explained the reason, they stressed the unsanitary condition created at the sites and the unbearable odor that come out of the solid wastes in the containers.

According to the results of the sample survey about 77.2% of the respondents supported that the odor created at the container sites in general has been so terrible that it has been an obstacle to properly use the containers.

Unfortunately, the response of the sample householders with respect to the aesthetic condition of the containers has been unexpected. Only about 43.1% of the sample householders have observed that the containers are not attractive and thus have reduced the aesthetic condition of the city.

The number of complaints regarding the physical condition, particularly size, of the containers are also so few. Only about 32.6% of the respondents of the sample householders agreed that the containers have problems related to size, of which 56.5% noted that the containers are so large and so high. They added that, on the one hand, the size of the containers is an obstacle to place their wastes into them properly; on the other hand, they take so many days to fill and hence cannot be picked up for days.

Even though the response of the sample householders has not been supportive of my observation, I argue that the physical feature of the containers, in general, is not appropriate.

Normally, such types of containers are meant for enterprises, institutions and industries, which do have very high rate of generation of solid wastes. And rarely these big-sized containers are recommended for highly congested settlements.

The containers are difficult to be handled, particularly for children. Mostly, as I have observed, the children are so small that they either climb up the containers, stand on the waste and empty their receptacles or they simply dump it on the ground near the container. Most of the residents around the container, for instance, accuse the community for inappropriate use of the containers because they send small children to empty their receptacles into the containers.

Fig. 5 Beneficiaries Emptying their Receptacles into the Container



The low perception of the sample householders as regards the problem of the unsightly condition and the big size of the containers may be due to certain factors. Firstly, the educational background and of course the level of awareness of most of the sample householders is very low, that is they are either illiterate or can only read and write. Secondly,

domestic solid waste handling in most households is totally the responsibility of children or housemaid. So, most of the householders do not have contact personally with the containers. For instance, as indicated earlier, only about 31.3% of the sample householders dispose off their solid wastes to any alternatives themselves.

The Collection and Transportation Facilities (Vehicles)

The poor solid waste management system in general and the low level of solid waste collection and transportation service, particularly in Mekelle is partly due to the various problems associated with collection and transportation equipments. These include the inadequate number and inappropriate types of vehicles, and poor operation system.

From the very beginning, the Health Office has no capacity, at least with respect to collection vehicles, to provide satisfactory solid waste collection and transportation service. The number of collection vehicles involved in the city under the Health Office is so few that they can not overcome the whole burden of the city. Forgetting other problems related with the vehicles and operation system, all the vehicles, the Health Office owned, cannot collect and dispose off half of the solid waste generated in the city as a whole.

If we consider the total number of collection vehicles owned by the Health Office (whether it is currently functional or non-functional), the regular working days' programme as indicated by the office, the optimum number of round trips from Mekelle to the disposal site, and optimum carry capacity of the vehicles as indicated by the office, it would be possible to estimate the potential of the Health Office to collect and dispose off solid waste in a specific

time. The total number of vehicles is taken as four tractors (as it was at beginning of the 2001) and 2 skip-loaders; the optimum number of trips in a day is four for skip-loaders, and two for tractors; and the total number of working days (Monday-Friday) is taken as 22 days in a Month. This means that totally about 716,320 kg of solid waste, where 520,960kg by skip-loaders and 195,360 kg by tractor would have been collected in a month. And this could have accounted for the collection and disposal of about 46% of the total solid waste generated in the city in a month. (See table 12).

Table 12. Potential of the Health Office to collect and dispose off solid waste in a month

Types of vehicle	Number of vehicles	Optimum no. of trips per vehicle in a day (no. trips /veh/day)	Carrying capacity- m3/veh/trip. (Kg/veh./trip)	Total qnt. of S.W collected in a day m3/day/veh. (Kg/day/veh)	Total qnt. Of S.W coll. in a month m3/month/veh. (Kg/month/veh.)
Skip-Loaders	2	4	8 (2960)	64 (23680)	1408 (520960)
Tractor	4	2	3 (1110)	24 (8880)	528 (195360)
Total					1936 (716320)

Therefore, we can say that the Health Office, even using all the collection vehicles it currently owned, cannot give satisfactory solid waste management service to the city. It has significant shortage of vehicles.

When we see the practical situation of the Health Office with respect to the collection and transportation vehicles it owns, the number of currently, more or less regularly, functioning vehicles is by far lower than what was at the beginning of the year 2001. There has been on the average two tractors functioning in a month. And this problem is more or less connected with the inappropriateness of the vehicles.

It is possible to evaluate the appropriateness of the vehicles in terms of their model and quality. The question of appropriateness specifically refers to the tractors. After all the tractors are not appropriate model for solid waste collection and transportation service particularly in Mekelle for many reasons. The carrying capacity, speed and physical design of their carriage are some of the main issues of the tractors that have to be considered. It is very difficult for the tractors to make frequent round trips between Mekelle and the disposal site. When the distance and the nature of the road to the disposal site is considered, the disposal site is too far to turn around frequently provided that the speed of the tractors is so slow. The Health Office has estimated the time taken for one round trip for the tractors as over 3 hours.

The carrying capacity of the tractors is also so small that it does not match with the haul distance. It is carrying only 3m³ that they travel such very long distance for so many hours. The tractor-service would have been better had there been a transfer station. Moreover, the physical design of the tractor carriage, being open-top fully, is not proper for solid waste collection and transportation because the waste is exposed to wind, and the waste creates unsightly condition.

The tractors are also more liable to damage. This could be partly due to poor quality, the transport or road situation, lack of maintenance and service, and/or mishandling by the drivers. However, whatever the case, the tractors are frequently exposed to damage. That is why the number of trips they perform in a day or in a month has been below the optimum number of trips per tractor. The tractors have conducted on the average, 1.7 trips per vehicle per working day in 2001, excluding August and September during which they were totally absent. For instance, in January and February the average number of trips per tractor per working day was only 1.5. This implies that the tractor-services are irregular and unreliable.

And this could be mainly due to the fact that the tractors are not appropriate for solid waste collection and transportation in the city.

In fact the skip-loaders have also been performing lower number of trips than their optimum number of trips. For instance, the average number of trips per vehicle per working day of the skip-loaders is 2.8 in 2001. And the minimum number of trips has been performed in May, where on the average only 2.2 trips were conducted by a skip-loader in a working day. But the reason could be mainly due to the operation system (principle) of the Health Office, in that a container is assumed to be collected only if it is full.

Operation system

The operational system of the collection and transportation of solid wastes has also contributed to the poor solid waste management service in the city in many ways. Firstly, the collection vehicles have no well-defined working programmes (schedule). The tractors have no defined route of collection and collection points. Though, theoretically, they have a programme that describes the day and the respective Tabia during which it is assumed to be served, the route of collection and collection-points have been determined by the good-will of the drivers. Moreover, there have no regular mechanisms of supervision.

As far as the Operations System of the skip-loaders is concerned, two main shortcomings are observed. Firstly, the principle of the Health Office, ‘to collect containers only if after they have been full’, has many consequences. On the one hand, as the containers are extremely full and a substantial portion of the waste is exposed for falling in streets and roads while containers are transported.

Fig. 6 Container While Picked up by the Skip Loader



Secondly, some containers are stay for a number of days before collection, until they have are full. As mention earlier, this causes the creation of unbearable smell at the container sites.

Another shortcomings of the operational systems of the skip-loaders is the way information is acquired about the condition of the containers. Almost all the means , that the Health Office has claimed to use, for getting information are not reliable and efficient. Therefore, it needs specifically assigned informants at each site. So many containers have been forgotten, left uncollected for so many days after they have been full.

5.3.2. The Budget

The budget of the solid waste management has being coming directly from the Public Administration of the city. Based on the request of the Section, through the Health Office, the Administration body of the city allocate budget to the sold waste management service.

Indeed, the amount of recurrent budget allocated for the solid waste management service has been steadily increasing since the budget year of 1992 E.C (see table 13). Unfortunately, I could not get data about the total amount of budget requested by the Section for solid waste management. Of course, according to the explanation of the Finance and Budget Section of the Health Office, almost all the budget requested by the Section for solid waste management has been released and used.

Table 13. Amount of Budget used by the solid waste management service, by year

Types of expenditure	Expenditure (birr)					
	1992		1993		1994	
	Rec.Bud	Cap.Bud	Rec.Bud	Cap. Bud	Rec.Bud	Cap. Bud
Perdiam	14000.00	9406.25	47124.00	-	20,000.00	-
Maintenance of vehicle	25,035.40	-	35854.00	-	75000.00	-
Uniform	12,169.13	-	9800.00	-	18000.00	-
Fuel	33,372.24	-	100,000.00	-	73022.60	-
Sanitation materials	-	-	6000.00	-	10948.00	-
Stationary materials	-	-	-	-	3800.00	-
Announcement	3527.00	-	-	-	-	-
Landfill construction	-	723,588.57	-	-	-	-
Purchasing of vehicles	-	1444,456.50	-	-	-	-
Purchasing of containers	-	385483.39	-	-	-	-
Tax of Vehicles	-	224,038.34	-	-	-	-
Payment for peasants	-	20679.75	-	-	-	-
Rental for Dozer	-	39924.80	-	-	-	-
Total	88103.77	2547577.60	198778.00		200947.60	

Rec Bud: Recurrent Budget

Cap Bud: Capital Budget

Source. Health Office, Finance and Budget Section

The recurrent budget expenditure of 1993 has been increased by about 110,674.25 birr (or 125.6%) from the previous years (i.e 1992). In 1994 E.C, the total expenditure of eight months has been greater than the total expenditure of the whole year of the 1993 E.C This all shows that the recurrent budget allocation as well as expenditure has steadily increased since

1992 E.C. The capital budget as indicated in the table has been that of 1992 and 1993 Fiscal Year.

However, when the budget expenditure is compared to the total solid waste generated, there was only about one cents (0.01 birr) of recurrent budget allocated for collecting and disposing of 1kg of solid waste in 1993 Fiscal Year. This means that one Ethiopian birr has been allocated for collecting and disposing of 100 kg of waste. This is obviously a far less from what is required to collect and dispose the large volume of solid waste that is generated in the city every day.

But practically when we calculate the amount of budget expenditure per unit performances (per unit quantity of solid waste collected and disposed off formally in 1993 Fiscal year), Birr 0.03 is spent for 1 kilogram solid waste collection and disposal service from the recurrent budget. In other words 1 kilograms of solid waste costs Birr 0.03 to collect and to dispose off. This implies that there has been an extreme shortage of budget allocated to solid waste management service by the responsible body.

If we calculate the total amount of recurrent budget required to collect and dispose off the solid wastes produced in the year based on the rate of 1993 fiscal year. i.e 0.03 birr for 1 kg. solid waste (3 birr per 100kg waste), the 1993's recurrent budget has been deficient by Birr 369,444.87. In other words, based on the rate of 1993 Fiscal year, about Birr 568,222.87 of recurrent budget would have been required to collect and dispose off about 14524408.3kg of solid waste produced in the year, where only 34.98% of it has been allocated and used.

Year	Tot. S.W. gen. (kg.)	Tot Rec. Bud. Allo.) (exp.) (Birr)	Rec. Bud./unit S.W. gen (Birr/kg)	Tot. S. W. coll. (Kg)	Rec. Bud. Exp. per unit S. W. coll (Birr/kg)
1993	14524408.3	198778	0.01	6387680	0.03

5.2.3. The Rules and Regulations of Domestic Solid Waste Management in Mekelle

The rules and regulations of Environmental Hygiene of the Tigray National Regional State adopted in 1987 E.C are the only document used for solid management in Mekelle. Mekelle has no its own rules and regulations specific to solid waste management. The rules and regulation and their implementation programme of the region are by nature more general. Therefore, Mekelle needs detailed rules and regulations and ordinance accompanied by penalties that clearly shows all the responsibilities of the beneficiaries, the types of the solid wastes permitted to be placed in the public containers and tractor-carriages, the working system of the service giving agent, etc.

Moreover, the efforts made to practice the rules and regulations specifically related to the solid waste management are weak. On the one hand there was no strict follow-up; and the penalties connected with domestic solid waste is only about one issue, that says when ever a solid waste is identified thrown away with in 20 meters distance from his/her home he/she will be penalized birr 15.

On the other hand, there was no little effort made to create awareness about solid waste management in the community including the rules and regulations and associated penalties.

For instance, about 64.1 % of the sample households reported that either there is no or they do not know about the presence of rules and regulations related with solid waste management. Most of the residents know only the statement indicated above. The residents were also complaining about the inadequacy of the follow-up and weakness of the penalties. About 83.2 % agreed that the follow-up to practice the rules and regulations of essentially the environmental hygiene was not strong. And 87 % of the respondents believed that the penalties were too low to prevent violation of the rules and regulations. Moreover, about 57.2

% of the respondents reported that they did not achieved any form of education related with solid waste management (See Appendix A-4)

5.2.4. The Disposal Site and Technique

The two most important issues of solid waste management regarding disposal of solid waste are the selection of site and the disposal technique. A disposal site has to be selected so that it has no social and environmental consequences. Based on certain criteria, though I could not come across documented data about the selection criteria applied by the Ad Hoc committee, it might be possible to estimate what could have been the general point of emphasis regarding the site selection criteria by simply looking at the representatives (members of the committee and their representing offices). According to my personal observation, the criterion such as the natural condition, land use, public acceptability and safety (as proposed by Rushbrook, 1999) have been satisfactorily fulfilled. However, as far as the transport-related aspect is concerned either it has been underestimated or outsmarted by the other criteria. The very steep road at Mt Messebo undoubtedly would have been a strong challenge to the collection vehicles, particularly to the tractors. The frequent movement of the vehicles along this steep road can expose them to frequent damage and thus shorten their life span. Moreover there is hardly any doubt that it reduces the frequency of trips made by the vehicles.

Fig. 8 The Collection Vehicles Emptying their Load at the Disposal Site

- a. Skip-loader



b. Tractor Carriage

As far as the disposal technique is concerned, it is an accepted, uncontrolled technique. Open dumping, though still one of the most widely used methods has many adverse consequences, both social as well as environmental. The light materials like plastics and paper are seen widely distributed around the disposal site. Moreover, irregularly dumped piles of wastes have created unsightly condition at the site. In general, the open dump of the Messebo disposal site has created unsanitary condition at the site.

5.3. The Socio Cultural Factor

The poor domestic solid waste management that has been prevailing in Mekelle partly owes to the communities' bad practice with respect to solid waste management. The community has in many ways aggravated the problem of solid waste management and even in some cases created the problem. Fortunately both the residents themselves as well as the workers of the solid waste management service provision have agreed that the community of Mekelle is equally responsible for the poor solid waste management system in the city. About 75.98% and 68.18% of the sample households and the sample workers of the solid waste management respectively have agreed that the community is responsible for the occurrences of the problems of solid waste management in the city (See Appendix B- 1 and 2).

The bad practices of the community with respect to solid waste management have been manifested mainly in three ways: dumping of solid waste illegally anywhere in the city, mishandling of waste at home, and improper use of containers. Most of the residents have not properly handled their wastes at home. And this can be reflected in the nature and types of receptacles used, and the duration during which solid wastes stay at home before collection or before they are emptied into the containers.

The materials used by the community as receptacles are of varied types such as sacks made up of either sisal or synthetic fibers, small plastic bags, plastic and metal bucket, iron

sheets, carton, etc. whose sizes are not standardized. However, the problem is not only the size of the materials it is also the fact that almost all of these receptacles are extremely damaged. The nature of the receptacles used by the residents such that they are predominately used and old materials, which have been out of use for a long time due to various defects. It is uncommon to come across receptacles that are either new or are originally produced for this purpose. It is only after they have been exhaustively used for some other purposes that almost all the materials are converted to receptacles. In fact, the nature and even the types of the receptacles slightly vary among the residents of varied standard of living. As I have observed, most of the economically weak residents use relatively older, heavily damaged and temporary receptacles that may hardly serve the purposes.

Generally, there has been a tendency of using inappropriate materials for disposing waste. This implies that most of the receptacles cannot retain the solid waste properly; the wastes are liable to fall off and spread out within premises to become sources of health risks. Even when the receptacles are transported to the container or other alternatives, much of their content falls behind before it reaches the end point.

The responses of the sample householders, as regards the nature and type of receptacles are open and honest; almost 100% of them have admitted that the materials they usually use as receptacles are used and old. This causes mishandling of the solid wastes.

The length of time (duration) domestic solid wastes have been made to stay at home in the receptacles, before it is emptied into the secondary storage containers, to the door-to-door collection vehicles or to other alternatives is also an important variable to appraise the domestic solid waste handling system of the community. Generally I have observed that solid wastes are usually stayed long unnecessarily at home in Mekelle. Probably a good evidence to arrive at this conclusion is the bad odor that comes out of the receptacles while they are

emptied anywhere or are placed at home. For one thing most of the items (constituents) of the domestic solid wastes, as it has been indicated earlier, are putrescible like garbage, with large amount of moisture content. Moreover, the average day temperature of Mekelle is considerably high. So domestic solid wastes are more susceptible to decay and therefore create odor soon.

Normally, solid waste, particularly garbage is recommended to reach the final disposal sites within, at most, 8 days. Note that the 8 days do necessarily include the time they spend at home. About 65% of the respondents reported that could normally stay at home for seven days and above before they are emptied to the storage container or dumped elsewhere. And one can easily imagine how bad it would be when the waste stays in the containers for other additional days before it is collected.

Therefore, domestic solid wastes are generally poorly treated or handled at home, and this has partly aggravated the problem of solid waste management in the city.

Containers are usually not properly used by the residents. The residents usually do not place their solid wastes into the containers properly. Most of the wastes are dumped outside the containers, on the ground. Especially when the containers are swelling, approaching to be full, one hardly finds residents placing their waste properly in to it. The problem becomes worse when children ordered to do the job. Most of the children, as I have observed, are so small that they cannot discharge their responsibility properly. And we know that most of the community assigns this duty to children. For instance, about 45% of the sample households agreed that they use exceptionally their children, to throw out solid wastes into containers. And this has been one of the severe complaints of the residents dwelling nearby the containers as well as of the container-guards. They accuse the community for sending their children to empty receptacles into the container who are not only so small to reach the mouth of the

container but also not that it is not their responsibility. The misuse of the containers that is dumping outside of the container usually takes place, in the evening when the Container Guards have left for home. But it is also common during the day.

Fig. 9 Filled up Container and Waste Dumped Around



The dumping of domestic solid wastes anywhere in the city illegally is the usual phenomena in Mekelle. The Guards of the water courses that cross the city are ever busy to sweep collect and burn, and sometimes to transport the solid waste, dumped usually in the evening or early morning, into the nearby containers. For instance, the May Baekel river course, below the Adwa Film House area and near Agazi Commercial Bank of Ethiopia, has almost become a regular dumping site. The river course that almost separates Tabia Selam and Tabia Hayelom, and the river course lying on the way to Hawelti from Abrah Castel Hotel are also among the highly exposed areas to solid waste dumping.

The open-areas, that are usually relatively far from residential houses and areas for which there has no concern personally are prone to being of illegal dumping sites. The area around the building of Gereb Tsedo Elementary School and nearby religious institution, the open areas in front of the Adi Haki market area, the wide open area between Tabia Adi Haki and Adi Hawsi, the non-built up area of Tabia Sertse on the way to Referral Hospital, etc, are some of the most affected areas. Moreover, in the Mesheta areas of Tabia Zesilasie and Walta, Taiba Hareya (Jibruk) and the congested settlements of Tabia Dedebit solid wastes are frequently seen here and there.

Therefore, the bad practice of the community has greatly contributed to the poor solid waste management in the city. In fact, for most of the bad practice of the community, the poor and inadequate solid waste, management service has contributed much for the occurrences of most of the bad practices of the community. But it may not be the only reason, sometimes negligence and/or lack of awareness may have also played a role considerably.

As far as the responses of the community with respect to bad practice is concerned, it almost indirectly confirms my observation. About 46.3% of the sample householders agreed that they use open areas, river courses and depressed areas to dump solid wastes. Some households burn the solid waste that they have generated.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study has been conducted to address certain research questions. Some of the main research questions include: how much solid waste the average household in the city generates? What proportion of the solid waste generated in the city is collected and disposed off by the Health Office-Sanitation Section, and by the public through the cleanliness campaign? Which part of the city is better served by the solid waste management service?

What are the factors that constrain the solid waste management in the city? And what is the role of the legal aspects, if any, regarding solid waste management in the city?.

To answer these research questions the writer conducted a sample survey where two types of questionnaires were prepared and filled by households and workers of solid waste management unit. Moreover, the writer selected sample households of different income categories and measured the domestic solid waste generation rate of each household of the respective income groups.

The responsible body of solid waste management service, specifically the Health Office of the Especial Zone of Mekelle has not yet conducted a survey to estimate the rate of generation of solid waste in the city. It simply takes the rate of generation indicated in the research result conducted by the Prime Minister's Office for all urban areas of the country, that is, the 0.3kg/cap./day. Based on this rate it is estimated that in the year 2001 about 39792.9kg(107.55m³) of solid waste has been generated per day and 14524408.5kg of solid waste in the year. Of this, the highest proportion of solid waste originated from households (residences). For instance, based on the estimation on the proportion of the solid wastes generated in Addis Ababa by source, household solid waste account for 75%. If we apply this ratio to Mekelle about 29844.68 of solid waste has been generated per day, by households in Mekelle. This means that 10893308.2 kg of domestic solid waste was generated in the city in the year.

The results of the sample survey suggested that the amounts of solid waste generated by the higher, medium, and lower income households of Mekelle are 0.412kg, 0.301kg and 0.277kg per capita per day respectively.

The Health Office-Sanitation Section, which currently runs the solid waste management service in Mekelle could not provide a satisfactory solid waste management

service to the city. Currently it has also no capacity to give adequate, reliable solid waste collection and disposal service to the city. The quantity of solid waste that has been collected and disposed off to the final disposal site, somehow properly, by the Health Office is extremely low. It is only about 39.38% of the solid waste generated in the city.

The role of the public cleanliness-campaign is believed to be significant, but usually the solid wastes collected through the campaign are placed into the containers and tractors. But occasionally certain additional vehicles are involved in solid waste collection during neighborhood cleaning campaigns. However the amount of solid waste collected and disposed through such campaign has not been recorded. However, it is quite clear that the largest part of the solid waste produced in the city is left uncollected.

Solid waste management bodies poorly serve obviously all parts of the city. But certain areas are relatively more favored than others in certain aspects. For instance, the inner part of the city was better container service, at least as regards the distance traveled by the beneficiaries to reach storage containers. This implies that residents found in the inner part travel relatively shorter distance than those living in outer part of the city.

The poor solid waste management that prevails in the city is a product of various factors. Some of the factors that constrain the city's solid waste management are basically institutional as well as socio-cultural. The institutional factors are related to the organization such as structure, manpower, facilities, and amount budget and the rules and regulations of solid waste management service. The socio-cultural factor refers to the community's day-to-day practice in relation to solid waste management.

The structure of the organization of the solid waste management has been one of the factors that influence particularly the provision of solid waste management service in the city.

The organization of the solid waste management has been simple, loose and does not have a structure that matches the magnitude of its responsibility.

The manpower size of the solid waste management service of Mekelle has been extremely low. It does not match with the vastness of the job. There has been, on the average, one worker for about 1020 population to give solid waste management service. Moreover, the working moral and devotion of the workers has been greatly affected by various factors. The workers are complaining about many problems that they have come across. These include lower wages, bad recruitment conditions especially the temporary /contractual nature of work, the fact that are effected in kind (wheat) which is liable to irregularity and unreliability and mal-administration from their respective offices; and the ill attitude of the community towards them and their job.

The other important institutional factors are related to the facility of the solid waste management service. The facility mainly refers to the containers and the collection vehicles. Some of the problems related with the containers are quantity, distribution and placement (sitting).

The number of containers in the city is inadequate. The distribution of the containers, including tractor-service, over space and among the Tabias is not fair. On the one hand the containers are not distributed (or located) in the city in such a way that the beneficiary's optimum travel distance is secured. The beneficiaries travel extremely longer distances to reach the containers. The distribution of containers over space is also not oven, there is a tendency of concentration on a very small area that may be designated as the inner part of the city. In other wards, large member of containers are found in the inner part of the city.

The distribution of facilities (both containers and the tractor service) among Tabias has not been based on the quantity of domestic solid waste they have generated.

With regards to the sitting of containers many containers have not been sited at adequate open places (or areas), certain of them have been placed very near to dwelling houses, and some others have been close a large pedestrian traffic.

As far as vehicles are concerned, there are two skip-loaders and three tractors. Both the skip loaders as well as the tractors have their own shortcomings that aggravated the solid waste management problem of the city. The tractors are not appropriate to collect and transport solid waste up to 15 km distance to the disposal site. The steep road at Mt Messebo has worsened the problem of the tractors. The tractors, either because they are old or not properly handled, are also exposed to damage frequently. And that is why the number of functioning tractors is reduced, continuously and, since they have been frequently out of duty, the number of trips per tractor per day has been far less than the normal number of trips expected from them. Moreover, the tractors have no schedule that defines the collection routes and collection points of each vehicle on each working day.

The problem of the skip-loaders is mainly related to the principle and operational system of the Health Office-Sanitation Section. The principle of the section that containers are collected only if they have been full has caused certain containers to stay a number of days to be full and thus to be picked-up. This has exposed the containers to the risk of odor creation. The Health Office-Sanitation Section does not have an efficient and reliable means of acquiring information about the condition of the containers. So, due to this and other reasons containers stay un collected for a number of days after they have been full.

The budget, particularly recurrent budget allocated to and used by the solid waste management service of Mekelle in 1993E.C was much larger than that of 1992E.C. In 1994, almost the recurrent budget expenditure of 8 months has been greater than that of 1993E.C as a whole. But still the budget allocated to solid waste managements is not adequate. In 1993

E.C 0.01 birr was allocated to collect and dispose off 1kg of solid waste (i.e 1 birr to 100kg of solid waste).

As far as the rules and regulations of solid waste management are concerned, there have not been detailed rules and regulations specific to solid waste management in the city. So far, it is only the rules and regulations of Environmental hygiene and its implementation programmes in general of the region that has been available.

The socio-cultural factors refer mainly to the practice of the community. The community of Mekelle has contributed to the poor management of solid waste in the city in many ways. First, there has not been proper handling of solid waste at home, which manifested in the type of receptacles they use and the duration during which, solid wastes stay with in residential premises.

Secondly, the community does not properly place solid wastes in the containers. Thirdly, the community is throwing away wastes into river courser, open areas, etc. illegally.

6.2 Recommendation

Based on the findings of the study I would like to forward the following recommendations.

1. Many of the problems associated with solid waste management identified here are related to the lack of adequate emphasis from the responsible body. Therefore, solid waste management in general requires policy priority, that starts from adequate budget allocation
2. Solid waste management needs a structural organization that guarantees it a considerable autonomy in many aspects that facilitate self-contained activities up to the Tabia level.

3. The provision of solid waste management service requires adequate number and appropriate type and number of facilities. It has to have adequate and appropriate types of collection vehicles, with special emphasis to door-to-door collections service, if possible. Moreover, there have to be adequate number of containers.
4. Adequate attention has to be given to the distribution and sitting (placement) of containers. Containers have to be distributed in such a way that it matches with the distribution of population in number as well as in space. That means the density as well as the travel distance have to be taken into consideration.
5. The manpower size has to be increased to match with the magnitude of the burden of solid waste collection and transportation service in the city. Moreover, the recruitment type and payment condition has to be improved as far as possible so as to raise the working moral and devotion of the workers
6. The community has to be provided with adequate education and develop awareness how to handle its solid wastes at home and about the consequences of disposing solid wastes everywhere illegally, and of not placing solid wastes into the containers properly.
7. Since Mekelle is growing fast the problem of its solid waste is strengthening. Therefore, it requires detailed and strong rules and regulations of solid waste management accompanied by reasonable penalties.
8. The responsible body has no capacity to give a satisfactory service. Therefore it has to make efforts to attract private enterprises to be involved in solid waste collection and transportation service provision.
9. Mekelle needs to convert or upgrade the open dumping disposal site into controlled, accepted sanitary landfill disposal technique.

10. For most of the constituents of the domestic solid wastes are organic, it would be advisable to device mechanisms to convert them into compost and provide to peasants.

BIBLIOGRAPHY

- Benarde, Melvin A. (1971). *Our Precarious Habitat*. W.W. Norton and Co. Inc., New York.
- Berry, Brain J.L. (ed.) (1977). *The Social Burdens of Environmental Pollution: A Comparative Metropolitan Data Source*. Pugginger Publishing Company, Cambridge.
- CSA (1995). *Population and Housing Census: Tigray Region*. Vol. I and II, Addis Ababa.
- _____ (2000). *Demographic and Health Survey*. Addis Ababa.
- Davis, M.L. and Cornwell, A.D. (1991). *Introduction to Environmental Engineering*. (ed.). McGraw-Hill, New York.
- Department of Planning and Economic Development of Mekelle Zone (2000). A Sample Survey of the Sanitation Problems of Mekelle. Mekelle.
- Edelman, D.J. (ed.) (1997). *City Wide Best Practices in Solid Waste Management in Collection, Transportation and Disposal*. In N.U.D.S. Institute of Housing and Urban Development Studies, Rotterdam, the Motherlands.
- Hagerty, D.J., Pavoni, J.L., and Heer, John E., Jr.. (1973). *Solid Waste Management*. Van Nostrand Reinhold Company; New York.
- Harrison, Roy M.(1996). *Pollution: Causes, Effects and Control*. (ed.).Royal society of Chemistry, UK
- Hartshorn, Truman A. (1980). *Interpreting the City: An Urban Geography*. John Wiley and Sons, New York.
- 'Negarit Gazeta Tigr.' 6th Year No 4, 1986.
- NUPI(1993). *Mekelle Development Plan*. Final Report(Executive Summery). Addis Ababa.
- Mora, Joseph M. Morgan, Michael D.(1986). *Introduction to Environmental Science*. W.H. Freeman and Company, New York.

- Planning and Economic Development Bureau. (1998). *Atlas of Tigray*. Physical Planning Development, Mekelle.
- Rand, T., Hackohi, J., and Marxen, U. (2000). *Municipal Solid Waste Incineration: Requirements for a Successful Project*, World Bank, Washington D.C.
- Robinson, William D(1986). *The Solid Waste Handbook. A Practical Guide*. New York: John Wiley and Sons,Inc.
- Rushbrook, Philip and Pugh, Michael (1999). *Solid Waste Landfills in Middle and Lower Income Countries: A Technical Guide to Planning, Design and Operation*. World Bank, Washington D.C.
- Serageldin, Ismail and Cohe, Michael A. (ed.) (1999). *The Human Face of the Urban Environment: A Report to the Development Community*. The World Bank, Washington D.C.
- Serageldin, Ismail, Cohen, M.A. and Barrett, Richard (ed) (1995). *The Business of Sustainable Cities*. World Bank, Washington D.C.
- Slirrup, F.L., and P.C., F. Inst (1965). *Public Cleansing: refuse disposal*. Pergamon Press Ltd, Oxford. London. Edinburgh. New York. Paris. Frankfurt.
- Tchobanoglous, George, Theisen, M. and Eliassen, R. (1977). *Solid Wastes: Engineering Principles and Management Issues*. McGraw-Hill Kogakusha Ltd, Tokyo.
- _____(1993). *Integrated Solid Waste Management: Engineering Principles and Management Issues*. McGraw-Hill, Inc. New York.
- The International city Manager's Association (1953). *Municipal Public Works Administration*. Illinois, Chicago.

Thompson, Dixon and Van Bakel, Serena (1995). *A Practical Introduction to Environmental Management on Canadian Campuses*. The National Round Table on the Environment and the Economy, Canada.

UNCHS(Habitat) (n. d.). *Refuse Collection Vehicles for Developing Countries*. Nairobi, Kenya.

Glossary

Liwach: An informal activity which involves the exchange (sometimes the buying) of used items by other new goods from households

Town: The lowest Administration Unit in Ethiopia

Woreda: An Administraion Unit next Higher to Town in Ethiopia

APPENDIX A

Summary of the Sample Survey

1. Responses of the households towards the container services

The Types of the problems	Response		
	Type	No	%
1. The distance of the container sites from the household's premises has a problem	Yes	146	48.7
1.1 Containers are sited so far from the residents' houses	Yes	105	71.9
1.2 The distance from the container sites to most of the residents measured as greater than 200 meters of traveling distance	Yes	148	49.3
1.3 Containers are not sited/placed at adequate open place, they are too close to dwelling house	Yes	199	71.1
2. Containers are not distributed and sited on the city not based on the distribution and density of population, and optimum travel distances	Yes	159	53
3. Containers have problems related with their physical feature	Yes	93	32
3.1 Containers are so large and so high and thus are difficult to use them and do not fill up soon to be collected before their content decayed	Yes	52	56.5
3.2 Containers being with no lid have a problem to beneficiaries	Yes	187	64.3
3.3 The container sites in general related with the size of the containers and unsanitary condition of the site have created unsightly condition in the city	Yes	126	43.2
4. The bad odor created at container sites has been obstacle to use the containers properly	Yes	224	77.2

2. Responses of the householders towards the collection and transportation services

The types of the problems	Responses		
	Type	No	%
1. Container(s) is (are) not picked-up on time	Yes		
2. The contraire (s) around you is (are) not picked			
a. Once in 2 weeks and above	Yes	49	34.8
b. When ever it has been full	Yes	111	78.7
3. The tractors have no regular program of collection	Yes	188	78
4. The tractors are not visiting the beneficiaries frequently	Yes	193	93.7
5. The tractors usually do not visit the beneficiaries once a week and less.	Yes	192	79.7
6. The beneficiaries do not know the time and date when the tractors visit them	Yes	187	85.8
7. There is disparity in the provision of service where	Yes		
7.1 the inner parts are more favored than the outer parts of the city	Yes	90	88.2
7.2 the dwelling areas of the riches are better served areas than of the poor	Yes	55	82.1
7.3 Business and office are better served are more favored than the residential areas	Yes	63	75.9
7.4 the dwelling areas of the officials than of the ordinary people	Yes	60	75
8. The contribution of the cleanliness campaign to solve the problem of solid waste in the city is significant	Yes	252	88.4

3. Responses of the households towards the communities practice associated with solid waste management

Types of the problems	Responses		
	Type	No	%
1. The community of Mekelle is responsible for the poor solid waste management of the city	Yes	227	76
2. Solid wastes are frequently seen thrown everywhere illegally in the city	Yes	228	79.2
3. Residents use many options to dispose their solid wastes other than the containers and the tractors like open areas, river-courses, burning, etc	Yes	139	59.9
4. The receptacles used at home by the residents are used and old	Yes	294	99
5. Solid wastes swept and collected in receptacles at home are usually stay for 7 days and above before they are emptied to containers, tractors or elsewhere	Yes	182	61.9
6. The responsibility of disposing solid wastes in the households lies upon children.	Yes	135	45
7. The community does not place its wastes or empty its receptacles into the containers properly	Yes	138	51.7

4. Response of the householders towards the rules and regulations of solid waste management

Types of the problems	Responses		
	Type	No	%
1. The community (residents) do(es) not know the presence of rules and regulations of related to solid waste management in Mekelle	Yes	184	64.1
2. There is no or weak follow-up to make the rules and regulation of solid waste management be obeyed	Yes	218	83.2
3. Violators are not or rarely penalized	Yes	230	81.3
4. The penalties are not strong enough to prevent any types of violation of the rules and regulations of the solid waste management	Yes	220	87
5. The community has acquired no or little education about solid waste management	Yes	159	57.19

5. Responses of the workers of solid waste management towards the shortcomings of the Health Office-Sanitation Section

Types of the Problems	Response		
	Type	No	%
1. Health Office-Sanitation Section is responsible for the city's poor solid waste management.	Yes	22	100
2. The shortcomings of the Health Office-Sanitation Section-Solid waste management are related with			
a. Lack of appropriate organizational structure	Yes	20	90.1
b. Mal-administration	Yes	20	90.1
c. Shortage of Manpower	Yes	14	63.6
d. Shortage of budget	Yes	18	81.8
e. Inadequate and inappropriate facilities	Yes	15	68.2
f. The workers' low working moral and devotion	Yes	15	68.2
g. Others			
3. The very low working moral and devotion of the employees of the solid waste management owes to			
a. Lower payment (salary)	Yes	20	90.1
b. Un fair recruitment condition (i.e ever temporary or contractual)	Yes	14	63.6
c. The community's ill attitude towards the job and the workers	Yes	16	72.7
d. Vastness of the job that does not match with the existing manpower size	Yes	15	68.2
e. Mal-administration of their office	Yes	19	86.4
f. Others unfair irregularity and unreliability of payment, kind of payment, etc.	Yes	16	72.7

6. Response of the workers towards the solid waste management service

Types of the problems	Response		
	Type	No	%
1. The problem of solid wastes in Mekelle is strong	Yes	13	59.01
2. The Health Office is responsible for the poor solid waste management in the city	Yes	21	95.45
3. Solid water are frequently thrown every where in the city illegally by the residents	Yes	22	100
4. Containers are not sited based on the distribution and density of population and optimum travel distance	Yes	15	71.4
5. There is disparity in solid waste management service provision between			
a. The inner parts are more favored than the outer parts of the city	Yes	16	94.11
b. The dwelling areas of the riches are more favored than of the poor	Yes	12	75.00
c. Business and office areas are better served than the residential areas	Yes	-	-
d. The dwelling areas of the officials are better served than of the ordinary people	Yes	7	58.33
6. There is no strong follow-up to practice the rules and regulations related with solid waste management	Yes	16	72.72
7. The penalties are not strong enough to prevent violation	Yes	14	70
8. The contribution of the cleanliness-campaign to reduce the problem of solid waste in the city is significant	Yes	13	59.09

Appendix B

Annual Total Quantity of Solid Waste Collected and Disposed in Addis Ababa, 1984-1993
Fiscal Year

S.N.	Years (Fiscal Year)	Total Solid Waste Disposed (m3)*	Annual Change	
			Absolute Size (m3)	Ratio (%)
1	1984	168,588		
2	1985	186,742	+18,154	+10.7
3	1986	203,809	+17,067	+9.13
4	1987	281,633	+77,824	+38.18
5	1988	275,200	-6,433	-0.29
6	1989	264,049	-11,151	-4.04
7	1990	317,377	+53,328	+20.10
8	1991	362,797	+45,420	+14.31
9	1992	393,972	+31,175	+8.59
10	1993	449,431**	+55,459	14.07

*Source the Solid Waste Management Department Document

** Calculated based on the data of 11 months

Appendix C

Addis Ababa University
School of Graduate Studies
Department of Geography

A Questionnaire on the Solid Waste Management System in Mekele City

This is a questionnaire on the solid waste management system in Mekele city to be filled by the residents.

Deer respondents, I would like to primarily inform you that this questionnaire is for academic purpose only; that is, to collect information for MA Thesis in the Addis Ababa University School of Graduate Studies of Geography Department.

Besides, the outcomes of this research may help efforts made by the responsible (or concerned) bodies or individuals to resolve or mitigate the problems of solid waste management in the city.

Thus, respondents by understanding the importance of this research work, I kindly request you to fill this questionnaire honestly with out any hesitation. For all your cooperation and dedication I thank you in advance.

- N.B.**
1. This questionnaire is filled by the households, preferably by female householders (house wife), and a maidservant or any female responsible for house keeping
 2. You are not required to fill in (write) your name
 3. You are asked to respond to each and every questions included within the questionnaire
 4. You are required to return back the questionnaire, after you completed, to the researcher (or his assistants) soon, preferably within 3 days.

This questionnaire is to be filled by Residents (householder)

Part I

Woreda: _____ Tibia: _____

Sex: Male ☐ Female ☐

Education: Illiterate ☐ reading and writing ☐ primary ☐
Secondary ☐ 12th complete and above ☐

Income of the household total: Monthly (Birr) _____

Occupation _____

Family size _____

Part II

1. How do you evaluate the problem of solid waste in Mekele?

- a. Very high ☐ c. Moderate ☐ e. No problem ☐
b. High ☐ d. Little ☐

2. If your answer for question No.1 is "Very high " or "High" then who do you think is mainly (believe) responsible for the problem?

- a. The Municipality (or the health office) of Mekele ☐
b. The community of Mekele ☐
c. Both, equally ☐
d. Other _____

3. Have you ever seen solid wastes (whether from residents, business houses or institutions) thrown away (dumped) in dwellings, street or along-road sides?

- a. Yes ☐ b. No ☐

4. If your answer for question number 3 is "yes", then how frequent do you come across these solid wastes thrown away illegally?

- a. Always ☐ b. So many times (usually) ☐ d. often ☐
c. Sometimes ☐ e. Rarely ☐

5. Do you use the community storage containers to dump (to throw into) your solid wastes?

- a. Yes, always ☐ c. Yes, sometimes ☐ e. No, I don't ☐
b. Yes, usually ☐ d. Yes, rarely ☐

6. If you have another alternative to throw out your solid waste, what type is it ?

- | | |
|-------------------------------------|------------------|
| a. Open dumping areas | b. River courses |
| c. Ditches | d. Burning |
| e. Door-to-Door Collection Vehicles | f. Other _____ |

7. Rank the types of constituents(individual items) of your wastes interims of their proportion in volume of all of the following.

	1st	2nd	3rd	4th	5th	6th +
a) Ash						
b) Food Waste						
c) Wood						
d) Grasses and leaves						
e) Paper and Cardboard						
f) Plastics						
g) Metals						
h) Bones						
i) Ceramics						
j) Glass						

8. Do you use any item of your waste for any other purpose? Mention?

9. What type of receptacles (primary storage containers) do you usually use in your home or premises?

a. Sacks	Old	New
b. Metal vessel	Old	New
c. Plastic vessel	Old	New
d. Cardboard	Old	New
e. Plastic bag	Old	New

f. Mention others, if any? _____

10. Who usually empties (throws away) your receptacle to either the community storage container, or any other alternatives?

a. Yourself (householder)		c. Your house servant	
b. Your children		d. Paid porters (carries)	
		e. Your guard	
f. Other _____			

11. How frequent do you usually empty your waste (receptacles) to either containers, to the nearby river courses, ditches, or open dump areas, to the door-to-door collection vehicle?
- a. Everyday ☐ c. Every 4 to 7 days ☐ e. Every 13 to 21 days ☐
b. Every 2 to 3 days ☐ d. Every 8 to 12 days ☐ f. After 21 days ☐
12. What time do you prefer to empty your receptacles?
- a. Early-morning ☐ c. Noon ☐ e. Night ☐
b. Late-morning ☐ d. After noon ☐
13. Does the distance from your home to the nearest container cause you a problem to use it?
- a. Yes ☐ b. No ☐
14. If your answer to question number 12 is 'Yes', is it because it is?
- a. Very far ☐ c. Mention, if any other ☐ b. Very close to your home ☐
15. How much do you estimate the average distance from your home to the nearest container?
- a. 5-15 meters ☐ c. 51- 100 meters ☐ e. 201-300 meters ☐
b. 15-50 meters ☐ d. 10-200 meters ☐ f. 301-400 meters ☐
g. 401-500 meters ☐ h. > 500 meters ☐
16. Does the size of the community storage cause you a problem to use it?
- a. Yes ☐ b. No ☐
17. If your answer for question number 15 is "yes", why?
- a. Because it is too large (too high) to use ☐
b. Because it is too large to fill up and hence the waste in it decays ☐
c. Because it is too small so it becomes full soon ☐
d. Mention, if any other? _____
18. Within how many days does the container around your home usually fill up?
- a. Within 1 day ☐ b. Within 2-3 days ☐ c. Within 4-7 days ☐
d. Within 8-14 days ☐ e. Within 15-21 days ☐ f. >21 days ☐
19. Is the foul odor (bad smell) that comes out of the wastes within the container a serious problem /obstacle to use it properly?
- a. Yes ☐ b. No ☐
20. Do you believe (think) that there is a problem in sitting of the community storage containers?
- a. Yes ☐ b. No ☐

1. Do you believe (think) that the distribution of the community storage containers within the city of Mekele is based on the density (number) of population, the container's distance to the beneficiary, and the presence of open space to place the containers?
 - a. Yes ☐ b. No ☐
22. Does the absence of lids to the containers have a problem?
 - a. Yes ☐ b. No ☐
23. Do you believe that the community storage container has created unsightly appearance and thus decreases the aesthetic condition of the city?
 - a. Yes ☐ b. No ☐
24. How do you evaluate your Tabia/ dwelling/, in comparison to the neighboring Tabias (dwelling)?
 - a. More clean ☐ b. Less clean ☐ c. No difference ☐
25. If your answer for question number 23 is 'less clean', why do you think?
 - a. Because the residents of your Tabia (dwellings) do not manage their solid wastes properly ☐
 - b. Because your Tabia (your dwelling) receives lower (limited) collection service ☐
 - c. Because there is no container in your Tabia (dwelling) or it is very far from your Tabia (dwellings) ☐
 - d. If any other, please describe?
 - e. _____
26. If your answer for question number 23 is 'more clean', why do you think?
 - a. Because the people (residents) of your Tabia (dwelling) manage their solid wastes properly ☐
 - b. Because your Tabia (dwelling) gets more collection service ☐
 - c. Because your Tabia (dwelling) have adequate containers at nearby ☐
 - d. If any other, mention? _____
27. Do you believe the residents of your Tabia (dwelling) usually place their wastes into the nearby container properly?
 - a. Yes ☐ b. No ☐

28. Do you believe that the solid wastes community storage container (s) near your home is (are) picked up on time by the collection vehicles?
- a. Yes ☐ b. No ☐
29. How frequent is the community storage container (s) you use is (are) usually picked up by the collection vehicle?
- a. Twice a week ☐ b. Once a week ☐ c. Once in two weeks ☐
d. Once in three weeks ☐ e. Once in a month ☐ f. As soon as it has been full ☐
g. Other _____
30. Does the collection vehicle pick up the container (s) around (or nearby to) your home regularly (on program)? a. Yes ☐ ~~b. No~~ ☐
31. Do tractor-carried visit your Tabia (settlement)
- a. Yes ☐ b. No ☐
32. If your answer to question no 31 is "yes" how frequent?
- a. always ☐ c. Sometimes ☐
b. Some many times ☐ d. Rarely ☐
33. If tractors-carriage visits your settlement (Tabia) how frequent?
- a. daily ☐
b. two or three times in a week ☐
c. Once in a week ☐
d. Once in two weeks ☐
e. Once in three weeks ☐
f. Once in a month ☐
g. Once in greater than a month ☐
h. It is not known ☐
34. Does the tractor-carriages do you know when (day and time) the tractor-carriage visits your Tabia (settlement) ?
- a. Yes ☐ b. No. ☐
35. Do you observe disparity in service provision of the collection vehicles between areas (dwellings) of lower-income residents and of higher income residents? a. Yes ☐
b. No ☐
36. If your answer for question number 30 is "Yes", which areas (Tabias or dwellings) are better served?
- a. The lower- income dwellings (areas) ☐
b. The higher- income dwellings (areas) ☐

37. Do you observe disparity in service provision of by the collection vehicles between the Tabias (areas) at or near the center of the city and the Tabias (areas) far from the center of the city?
- a. Yes ☐ b. No ☐
38. If your answer for question number 32 is "yes", which Tabias or areas are better served?
- a. Areas (Tabias) at or near the center of the town ☐
- b. Areas (Tabias) far from the center of the town ☐
39. Do you observe difference in service provision by the collection vehicles between the Tabias (areas) of higher officials residents and of the common (ordinary) people?
- a. Yes ☐ b. No ☐
40. If your answer for question number 34 is "yes", which Tabias (areas) are better served?
- a. Tabias (areas) of the higher officials residents ☐
- b. Tabias (areas) of the common (ordinary) people ☐
41. Do you observe difference in service provision by the collection vehicles between the residential areas and business and institutional (including offices) areas?
- a. Yes ☐ b. No ☐
42. If your answer for question number 36 is "yes", which areas do you believe are better served?
- a. Residential areas ☐ b. Institutional, business and office areas ☐
43. Do you know that there are rules and regulations of (about) solid waste management in Mekele city?
- a. Yes ☐ b. No ☐ c. I don't know ☐
44. How do you evaluate the follow-up by the responsible bodies to practice the rules and regulations of solid waste management in Mekele?
- a. Very strong ☐ b. Strong ☐ c. Fair ☐
- d. Weak ☐ e. There is no follow-up ☐
45. Have you ever seen when violators of rules and regulations of solid waste management are penalized?
- a. Always ☐ c. Sometimes ☐
- b. So many times ☐ d. Rarely ☐ e. No, I haven't seen ☐
46. How do you evaluate the strength of the penalties to prevent violators of solid waste management's rules and regulations?

- a. Very strong ☐ b. Strong ☐
 c. Fair ☐ d. Weak ☐ e. They do not prevent ☐

47. Have you ever come across any form of lesson associated with (about) solid waste management in Mekele? a. Yes ☐ b. No ☐

48. If your answer for question number 47 is "yes", through what method (means) did you get the lesson?

- a. In Tabia meetings ☐ c. From radio (Voice of Woyane Tigrary) ☐
 b. In health institutions ☐ d. In posters and photographs ☐
 f. If any other, mention _____

49. If your answer for question number 47 is "yes", how do you evaluate it?

- a. It is adequate ☐ b. It is inadequate ☐ c. It is insignificant ☐

50. Do you believe that the clean-up campaigns that are conducted occasionally (usually during the ceremony of Yekatit 11 and Ginbot 20) in the city Mekele are helpful and effective to clean up solid wastes (to solve the problem of solid wastes in the city)? a. Yes

- b. No ☐ ☐

51. If your answer for question number 50 is "No", could you describe some of the reasons?

52. Are you willing to pay certain amount of service charge for solid waste collection service?

- a. Yes ☐ b. No. ☐

53. Write any comment, if you have? _____

This questionnaire is to be filled by the workers of the solid waste management Agency

(Department) of Mekele

Sex: Male ☐ Female ☐ Tabia _____

Division of labour _____ Title _____

Service Year: _____

Employment Status: Contractual ☐ Permanent ☐

Educational Status:

Illiterate ☐ Secondary ☐ 12+2 ☐
Reading and writing ☐ 12th complete ☐ 12+4 and above ☐
Primary School ☐ 12 +1 ☐

Part II

1. How do you evaluate the problem of solid waste in Mekele?

a. Very Big ☐ c. Moderate ☐ e. No problem ☐
b. Big ☐ d. Little ☐

2. Have you ever come across solid wastes thrown away where in the town illegally

a. Yes ☐ b. No ☐

3. If your answer for question number 2 is "No", where does the main problem lies, according to your observation?

a) with the solid waste management agency ☐
b) with the communities (residents) of Mekele who produce the solid waste ☐
c) with both the solid waste management body and the communities (residents) ☐
d) Mention others, if any? _____

4. How do you explain the shortcomings of the responsible body (Health office)

4.1 There is no adequate number of containers sited at a satisfactory walking distance of the beneficiaries

a. Yes ☐ b.No. ☐

4.2 There are no adequate number of tractors

a. Yes ☐ No. ☐

4.3 There are no appropriate types of containers and door-to-door collecting vehicles

a. Yes ☐ b.No. ☐

4.4 The containers are not picked-up on time

a. Yes ☐ b. No. ☐

4.5 The tractors have no regular programme of collection

a. Yes ☐ b. No. ☐

4.6 Mention, if any other _____

5. If you believe that the solid waste management body is partly or wholly responsible for the occurrence of problems of solid waste management in the city,

5.1. Is it because it has shortage of labour force to cover the whole city?

Yes ☐ No ☐

5.2. Is it because it has mal-organizational structure and mismanagements?

Yes ☐ No ☐

5.3. Is it because it has shortage and in appropriate containers and collection vehicles?

Yes ☐ No ☐

5.4. Is it because of the lack of initiatives and working moral in the employees?

Yes ☐ No ☐

5.5. Mention others, if any? _____

6. If you believe that the lack of initiatives and working moral of the employees of the agency is a serious problem, what could be the reason?

6.1. Low payment (wages) in comparison to the weight of the work (job) ☐

6.2. The employment status, that is being contractual ☐

6.3. The negative attitude of the community towards the workers and the work (job), eg.

lowering the status of the workers and the work (job) ☐

6.4. The vastness of the work ☐

6.5. The community does not cooperate ☐

6.6. The mismanagement (misadministration) of the Agency ☐

6.7. Mention others, if any? _____

7. If you believe the communities (residents) are partly or wholly responsible for the problem of solid wastes in the city Mekele?

7.1. Is it because solid wastes are thrown out illegally any where by the residents (though not

all)? a. Yes ☐ b.No ☐

- 7.2. Is it because the communities (residents) of Mekele (though not all) do not place their solid wastes in the containers properly? a. Yes ☐ No ☐
- 7.3. Is it because the communities (residents) of Mekele (though not all) places wastes into the container that are not legally permitted? a. Yes ☐ ☐
- 7.4. Is it because the communities (residents) of Mekele (though not all) do not cooperate to the workers of the Agency? a. Yes ☐ b. No ☐
8. Do you believe (think) that there is a problem in sitting of the community storage containers?
a. Yes ☐ b. No ☐
9. Do you believe (think) that the distribution of the community storage containers within the city Mekele is based on the density (number) of population, the container's distance to the beneficiary, and the presence of open space to place the containers?
a. Yes ☐ b. No ☐
10. Does the containers have a problem connected with their size?
a. Yes ☐ b. No ☐
11. Do you believe that the community storage container have created unsightly appearance and thus decreases the aesthetic condition of the city?
a. Yes ☐ b. No ☐
12. Do you observe disparity in service provision of the collection vehicles between areas (dwellings) of lower-income residents and of higher income residents?
a. Yes ☐ b. No ☐
13. If your answer for question number 11 is "Yes", which areas (Tabias or dwellings) are better served?
a. The lower- income dwellings (areas) ☐
b. The higher- income dwellings (areas) ☐
14. Do you observe disparity in service provision of by the collection vehicles between the Tabias (areas) at or near the center of the city and the Tabias (areas) far from the center of the city?
a. Yes ☐ b.No ☐

15. If your answer for question number 13 is "yes", which Tabias or areas are better served?
- a. Areas (Tabias) at or near the center of the town ☐
- b. Areas (Tabias) far from the center of the town ☐
16. Do you observe difference in service provision by the collection vehicles between the Tabias (areas) of higher officials residents and of the common (ordinary) people?
- a. Yes ☐ b. No ☐
17. If your answer for question number 15 is "yes" , which Tabias (areas) are better served?
- a. Tabias (areas) of the higher officials residents ☐
- b. Tabias (areas) of the common (ordinary) people ☐
18. Do you observe difference in service provision by the collection vehicles between the residential areas and business and institutional (including offices) areas?
- a. Yes ☐ b. No ☐
19. If your answer for question number 17 is "yes", which areas do you believe are better served?
- a. Residential areas ☐ b. Institutional, business and office areas ☐
20. Do you know that there are rules and regulations of (about) solid waste management in the city Mekele?
- a. Yes, there is ☐ b. No, there is not ☐ c. I don't know ☐
21. How do you evaluate the follow-up by the responsible bodies to practice the rules and regulations of solid waste management in Mekele?
- a. Very strong ☐ b. Strong ☐ c. Fair ☐
- d. Weak ☐ e. There is no follow-up ☐
22. Have you ever seen when violators of rules and regulations of solid waste management are penalized?
- a. Always ☐
- b. So many times ☐ c. Sometimes ☐
- d. Rarely ☐ e. No, I haven't seen ☐
23. How do you evaluate the strength of the penalties to prevent violators of solid waste management's rules and regulations?
- a. Very strong ☐ b. Strong ☐
- c. Fair ☐ d. Weak ☐ e. They do not prevent ☐

24. Have you ever come across any form of lesson associated with solid waste management in Mekele? a. Yes b. No ☐ ☐
25. If your answer for question number 23 is "yes", through what method (means) did you get it ?
- a. In Tabia meetings ☐ c. From radio (Voice of *Woyane Tigrary*) ☐
- b. In health institutions ☐ d. In posters and photographs ☐
- c. If any other, mention _____
26. If your answer for question number 23 is "yes", how do you evaluate it?
- a. It is adequate ☐ b. It is inadequate ☐ c. It is insignificant ☐
27. Do you believe that the clean-up campaigns that are conducted occasionally (usually during the ceremony of Yekatit 11 and Ginbot 20) in the city Mekele are helpful and effective to clean up solid wastes (to solve the problem of solid wastes in the city)?
- a. Yes ☐ b. No ☐
28. If your answer for question number 27 is "No", could you describe some of the reasons?
- _____
29. Do you observe any major problem/ weakness/ pitfall of the Clean-up Campaign carried on in the city Mekele?
- a. Yes ☐ b. No ☐
30. If your answer to question number 29 is "yes", describe the major ones
- _____
- _____
- _____
31. Write any comment, if you have? _____
- _____
- _____
- _____

