

# Study of Hazardous Industrial Waste Management Practices and Development of Hazardous Industrial Waste Management Guidelines in Addis Ababa

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**Abstract**— Industries are also growing in the city and diverse industrial hazardous waste is being generated. All these waste streams are being collected, transported and disposed with the other municipal waste streams. A sustainably safe management system needs to be installed for the hazardous waste. Therefore, this study is conducted to assess hazardous waste management practice and design standard hazardous waste management guidelines. Industries generation hotspot points were randomly sampled for data generation and collected data were analyzed to determine generation rates per industry and per person for industrial waste. About 290 kg/industry/day of Industrial Hazardous wastes was generated in Addis Ababa. Regarding hazardous waste management practices in the industries hotspot areas, the survey shown that most of the hazardous wastes are not properly segregated and managed across all the three streams. Collection service is being rendered by small and micro enterprises in the city. However there are no occupational safety and health issues addressed with the system. Used chemical containers were sorted/collected and sold to people for reuse and there is no records concerning how empty containers were handled. In most cases hazardous wastes from garages and industries wastes reported to be burnt on open spaces which may lead to serious air pollution problem and health hazard from the emission. This brief assessment showed that no legally registered facilities have been established for the disposal of hazardous wastes. The assessment also revealed that most industries facilities that are regularly inspected do not meet the standard limit requirements set by the regulatory bodies. It also showed that there is no institutional system working on hazardous waste management system separately.

**Keywords**— Collection, handling, transportation, hazardous, industrial, waste.

## I. INTRODUCTION

Addis Ababa, whose population grew from about 2.1 million in the year 1994 to 2.7 million in 2007, is one of the fastest growing cities in Africa. Its current population is estimated to be exceeding 3 million and, apart from its sheer population size, the city is playing significant economic, social and cultural roles both at the national and international levels. Accordingly, the City has significant contribution to the national GDP owing to the concentration of various urban-based service orientated and manufacturing activities. The city, which is the Federal Capital, accounts for almost a quarter of the national urban population that is a mosaic of Ethiopia's multi ethnic and multicultural identities. On the other hand, being the home of the African Union, the Economic Commission for Africa, several specialized UN agencies and other international organizations and more than one hundred diplomatic missions, it is among the few most culturally and ethnically diverse cities in the world.

The city's rapid population and economic growth, coupled with discernible changes in lifestyles and consumption patterns of its residents and visitors that are associated with globalization and improved information and communication technology, contribute to dynamic changes in both the quantity and composition of solid waste to be generated in the city. In particular, the rapid growth of industry has accelerated the generation of industrial, hazardous/toxic. Yet, the city does not have a comprehensive, integrated and sustainable solid waste management plan to effectively respond to the complexities associated with such dynamics.

Despite the fact that the city has one of the most progressive solid waste management policies and rich experience in adopting decentralized solid waste management systems that gave impetus for the participation of the private sector, it only focused on the collection, transportation and disposal of mixed municipal and hazardous solid waste. Its aim is heavily relied on mitigating the adverse effect of municipal solid waste on public health and improving the city's image as a clean city. The city Administration is in the process of adopting a paradigm shift in the city's solid waste management system as illustrated by the political commitment to institutionalize efficient, effective and customer focused services through business process re-engineering (BPR) and the adoption of a balanced score card (BSC).

The city has established two solid waste management organizations i.e. Addis Ababa City Cleansing Management Agency for collection and transportation services and Addis Ababa City Solid Waste Recycling and Disposal Project office to recycling and disposal activities. The city administration has built four transfer stations and one sanitary landfill so as to promote integrated solid waste management system. But the consideration of hazardous waste management system separated from the municipal/general waste management is a missing part as a crucial element to realize the safety of waste management workers, health of society and environment. There is no adequate information about hazardous solid waste characterization and generation to design proper way of management system. There is a lack of locally adapted standards and guidelines.

Hence, a study has been conducted to assess the characterization, generation and prevailing management practice of hazardous waste in Addis Ababa. The study has conducted on industrial waste streams. Selected hazardous waste generators from potentially identified institutions/organizations of the three steams have been assessed for data collection. Industrial waste was also assessed basing upon its generation, characterization and management practices. The profile data will be utilized for the development of hazardous waste management guideline.

Approximately, 1200 large industrial enterprises are found in Addis Ababa city. The number, natures and capacity of the industries vary across the sub cities, but large majorities are located in Nefas Silk, Yeka and Akaki Kality sub cities. Most industries generate toxic, corrosive and explosive hazardous waste that needs extra special attention by the city government.

There are little hard facts available on the handling, collection, transport and disposal of different categories of hazardous and special wastes, there is no facility in the whole country for appropriate treatment and disposal of hazardous solid waste. As a normal practice; uncontrolled type landfill is being used to dispose variety of toxic and hazardous wastes without considering pre-treatment measures. The collection, transportation and disposal practices of solid waste are without the precaution of hazardous waste. The toxic and hazardous waste is being collected and transported in mixed ways and disposed together with the municipal waste. In general; there is no effective institutional system and specific regulations dealing specifically on hazardous, special and industrial wastes. There is no competent, well-staffed regulatory department that deals with such wastes, no studies, inventories and records made on the hazardous waste generators, no specialized facilities and institutions, no list made on the priority hazardous pollutants /red list/, no segregation of hazardous waste at source in a separate bin. Producers are not fully responsible to dispose this waste separately and also there is no facility prepared for such wastes. The problem would be complicated if special hazardous waste management system guidelines, directives and procedures is not prepared.

## II. METHODOLOGY

### A. Description of Study Area

Addis Ababa is a capital city of Ethiopia with great geographical diversity endowed with rich natural and human resource base, and yet it is one of the cities in the world with the seat of many higher international communities and diplomat like UNDP, UNHCR, UNICEF and USAID etc and the head quarter of AU, ECA.

The city has an area of 540 square kilometers, of which 18 square kilometers is rural. It lies between 2,000 and 3,000 meters above sea level. Despite its proximity to the equator, Addis Ababa enjoys a mild, Afro-Alpine temperate and warm temperate climate. The lowest and the highest annual average temperature are about 10°C and 25°C. Annual rainfall is around 1200 mm.

The population of Addis Ababa grew from about 2.1 million in the year 1994 to 2.7 million in 2007 and the annual

growth rate of 2.1%, is one of the fastest growing cities in Africa. Its current population is estimated to exceeding 3 million. Due to certain reasons like other developing countries, the city has experienced highly accelerated population growth. The rapid population increase of the city has been mainly attributable to natural urban population increase and internal migration. According to the country's 1994 population and housing census, out of the total population of the city, 46.7% were migrants from rural and other urban areas in Ethiopia (CSA, 1999:161). Currently, CSA notifies that birth rate of Addis Ababa city administration is 2.1% with average family size 4.1 persons. At the start 2011; the city has a population of 2,979,206 and if no exaggerated rural urban migration faces, at 2020, it will expected to have a total population of 3,599,003. The projection of population is described in table I below.

TABLE I. Population projection of Addis Ababa City.

Year	Number of household	Total population
2010	711535	2917295
2015	790309	3240270
2016	807081	3309036
2017	824209	3379260
2018	841701	3450975
2019	859563	3524212
2020	877847	3599003

The projection is calculated from initial population of 2010 CSA data with rate equal to 2.1% and statistical projection formula  $[P_n = P_o e^{(R/100) \times t}]$ , where R is rate of population growth, t is time in years, p<sub>o</sub> is initial population, p<sub>n</sub> is final population and e is common logarithm.

However, there is no formal economic classification of urban dwellers in Addis; we stratified the city into three city socioeconomic classes according to their housing structure. The poorest people lives where in the slummy area of the city like Cherkos, lideta/kereyu areas, Addis Ketema/Atobis Tera and other slum part of the city are categorized under the lower socio-economic classes. The second stratum is those people living in condominium houses which are considered to be middle level income population. The third class of the city dwellers is highest economic class; for which the income of the people is comparatively highest and those living in the well-constructed and furnished villa and multistory buildings in majority at Bole areas.

### B. Approaches

Both desk review and field based study approaches were used to achieve the goal of this assignment. Reviews of all the existing relevant documents such as previous hazardous waste management reports of different countries as a bench mark, socioeconomic features of the study population and etc, identification of gap, and organization of database and preparation of inception reports have also been carried out.

All available materials, and other pertinent data sources of previous studies concerning the site were reviewed and consulted and Preliminary hazardous waste study road map were prepared for the subsequent ground field study using the existing methodologies. Then assessment of the social, economic and environmental impact as well as generation and

characteristics of a hazardous waste, such as type and quantity were undertaken through physical observation and technical evaluation, and this was further assessed through desk studies using appropriate and up-to-date hazardous waste study and characterization methodology presented below.

**C. Types and Sources of Data Collection**








**a. Type of data**

Both primary and secondary data were collected. Primary data were generated from 10 industries and other relevant stakeholders and informants. Secondary data were collected from reports, journals, research papers and other related international and local literatures that are available in the websites.

**b. Relevant stakeholders as a data sources**

Various stakeholders have been selected for data sources for industrial waste streams. As could be seen in table II, the stakeholders selected for data sources are from government and non-government sectors.

TABLE II. List of stakeholders.

Industrial waste	
	Ministry of Industry/Trade
	Ethiopian Investment Authority
	Bureau of Trade and Industry
	Addis Ababa Cleansing Management Agency
	Addis Ababa Waste Recycling and Disposal Project Office
	Addis Ababa Environmental Protection Authority /AAEPA/
	Solid waste collection and transportation companies

**D. Sampling Techniques**

Both multi-layer purposive and systematic random sampling techniques were used to select sample industries for data collection. Also the industries were classified purposively according to the international industrial classification (ISIC) and then sample industries were taken from each class. About 10 industries were sampled from different ISIC classes. The type, quantity and prevailing management system of hazardous industrial waste was assessed by questionnaire from those industries.

In the other side; electronic waste profile was developed by taking primary and secondary data from relevant organizations and households. A Primary data was gathered from a randomly selected dismantling and assembling centres in the city also from sample households. Firstly, the households were stratified based on socio economic level according to their housing structure (convenience method). Bole surrounding with high multi-storey building and villas residential areas was selected as high class households. City residents of condominium houses were also been categorised under middle economic class. Households that are living at the slummy villages of Cherkos village lied under the lower economic class. Then, about 10 sample households of each class were taken from high, middle and lower class of the category.

**E. Data Collection**

Well organized hierarchal and networked level of data collection procedures was adopted to keep the quality of data collected. To regulate and keep the quality of data especially

for determining biomedical waste generation and characterization at health care institution; a collection procedural manual was prepared. The data collection tasks were categorised into seven groups. The last group that had two experts was allocated for industrial waste management data collection.

For Waste from Industrial waste, comparative study and analysis were considered using some comparable primary data and secondary data.

**F. Hazardous Waste Generation and Characterization**

Different approaches have been employed to characterize the three hazardous waste streams. Hazardous waste of industrial institutions was quantified from the secondary data taken from the ministry of industry and selected industrial establishment.

The characterization of industrial waste was done against the nature of waste according to international classification of industrial classification. The industries was first categorised according to ISIC numbers of UNIDO. Then, one sample of the industries was taken from every category. The solid waste was then quantified including its management practice.

**G. Analysis and Synthesis**

Following the field work, data compilation; clearing, analysis, prediction and report writing were done. Collected data was summarized in R\_Studio statistical analysis software. The result was summarized in tables and graphs using R. Projection was drawn using graphs and charts. Stella dynamic simulation modeling tool was employed to predict the hazardous waste generation rate in the future.

III. RESULTS AND DISCUSSION

**A. Industrial Waste**

**a. Trends of industrial growth and its challenges**

Even though, Ethiopia remains a predominantly agrarian country for ages, modern manufacturing was introduced to the Ethiopian economy toward the end of the 19th century. It was in 1896 that Holleta grain mill was set up. During 1927 to 1941 about 35 factories were established in Addis Ababa and Dire Dawa. Although the growth was not significant, this was after the completion of Ethio-Djibouti railway which cited as one of the contributing factor for such improvement (Mohammed, Ali, 2002; MOTI, 2004).

It was only in 1950 that deliberate strategy to encourage the expansion of industrial sector had evolved (Legal Notice No. 102, 1950), which had been also revised at times by then. The industrial growth, however, did not show a significant change in the next five decades. One of the reasons was the guiding Industrial development Strategy, which was mainly import substitution until 1991(MOTI, 2004).

The role of industry, however, has been at the core of the country’s economic planning efforts ever since the economic reform of 1990s. This reform heralded “free market economic system” as the backbone of Ethiopia’s efforts to advance socio-economic development and improve the welfare of the Ethiopian people (The Policy Framework Paper, 1998;).From a small base, the sector has shown remarkable progress and

between 1992 and 2001 has consistently registered GDP share in excess of 10% (CSA, 2002;).

Addis Ababa is one of the most industrialized regions in Ethiopia. The city which in 2001 accounted for 61% large and medium industrial establishments in the country had just less than 4% of the country's human population (CSA, 2001). The city's administration GDP originates mainly from the industrial sector. In 1995 industry shared 51% of the city's GDP. Presently, the sector accounts even more for the industrial sector grew at a rate of 26% during the 1990s (MOTI, 2004).

As shown in figure 1, the major industries in Addis Ababa are food and beverage, textile, tanneries, chemicals, rubber

and plastic, paper and paper products metallic and non-metallic mineral products and wood industries.

The capital city as the seat of the African Union and the headquarters of the United Nations Economic Commission for Africa and many international organizations, attracted different economic activities and manufacturing industries are to be mentioned. During the past decade the number of manufacturing industries was increased from 510 in 1997 to 753 in 2009 which accounts for 28.7% growth rate per annum. Trends of industrial growth in Addis Ababa are shown in figure 2.

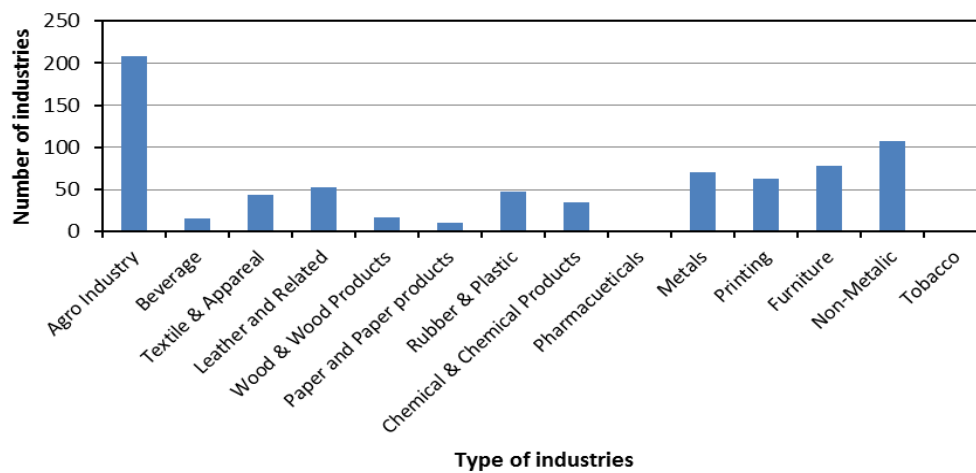


Fig. 1. Medium and large scale manufacturing industries in Addis Ababa (CSA, 2009).

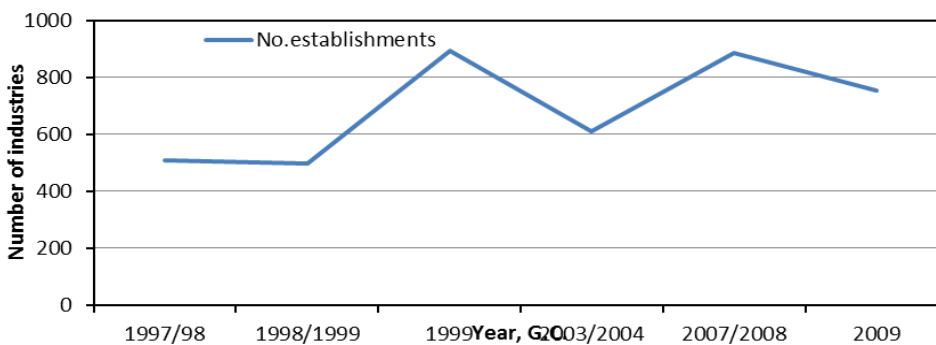


Fig. 2. Industrial growth trends in Addis Ababa, Ethiopia (CSA, 2009).

**b. Industrial hazardous wastes estimation**

The result of secondary data collected from Cleansing management agency and private waste collection companies showed that higher amount of toxic, corrosive and other flammable hazardous waste are generated, collected and transported to the landfill by business as usual method of waste management system. The quantification and characterization of industrial non-hazardous wastes in Addis Ababa were done according to its ISIC in the following way as described in table III.

The quantity of waste generated by ISIC category sampled industry was collected from the data of private waste collection company and compiled by questionnaire from the

industry. Finally, the analysis result was used for generalization at ISIC industrial category level. Accordingly, the study observed that the beverage sector has the highest waste generation rate per month (51m<sup>3</sup>), followed by Rubber & plastic (31m<sup>3</sup>) and printing industry (25m<sup>3</sup>). However in terms of total number of establishment, the food sector has the highest number (208m<sup>3</sup>). Accordingly, the quantity waste estimated from this sector is estimated to be 2766.44 m<sup>3</sup>, followed by Printing and Rubber & Plastic sectors 1850 and 1457 m<sup>3</sup> respectively.

The waste generation rate per day per industry is found to be 1.24 m<sup>3</sup>. The type of waste generated from the manufacturing industries varied depending on the sector. For



instance; wastes from tanneries contain mainly chrome tanned trimmings and fleshing wastes whereas wastes from the beverage industries characterized by broken glasses, corks etc.

TABLE III. Estimation of industrial hazardous solid wastes generated in Addis Ababa (Ton/year).

Industry Category	Characteristics	Mean	No. Establishment	Total
Beverage	Corrosive	1454	16	23265
Chemical, Gas & paint, soap & detergent	Corrosive & Toxic	803.2	35	28112
Rubber & Plastic (Foam)	Toxic	66	47	3102
Leather & related	Toxic	1814.5	53	96169
Woodwork	Toxic	0.144	17	2

According to findings of the available data, industries were considered in to five broad categories. These include

beverage, chemical and chemical products, tanneries, wood and wood products, printing, paper and paper products were considered. Consequently, the mean value per day per industry is found to be 0.29 ton and the types of wastes from these industries are characterized mainly as toxic and corrosive. Those wastes from the beverage industries have corrosive nature whereas the wastes from paint or tanneries do have toxic characteristics.

c. Projection of industrial solid wastes

As shown in figure 3 and Figure 4, the projection of manufacturing industries and the quantity of industrial non-hazardous waste in Addis Ababa; the industries grow by 26% growth rate and the waste generation are calculated and projected according to the assumption of similar growth rate until 2020. By 2020, the total number of industries is expected to reach 1665 and its waste generation will reach 1294 meter cube which is about 426.9 tonnes.

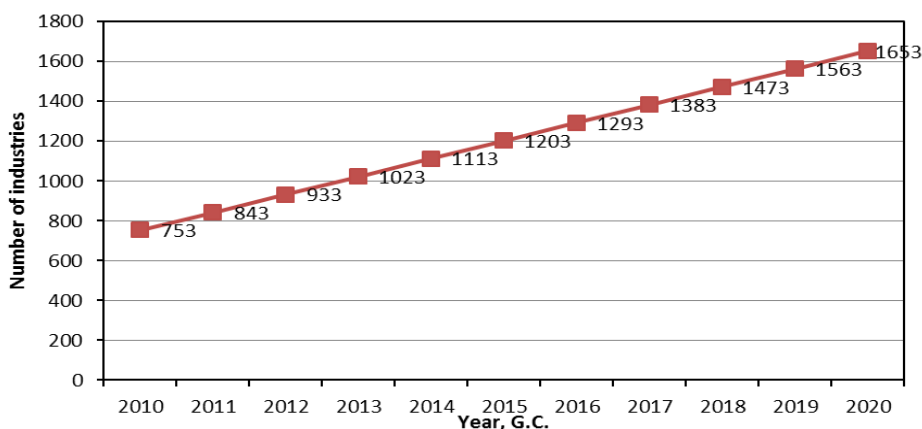


Figure 3 Projection of Manufacturing Industries in Addis Ababa (2010-2020)

Projected data for quantities of industrial non-hazardous wastes in Addis Ababa are based on the assumption that the city will incur a steady economic and social development. The trends are extrapolated over the next 5 years. Therefore, assuming that the waste that is being generated from the

industries remains constant, the quantity of waste from manufacturing sectors is expected to grow by 64 m<sup>3</sup> per annum and reaches to 1294 m<sup>3</sup> (426.9 tonnes) at the end of 2020.

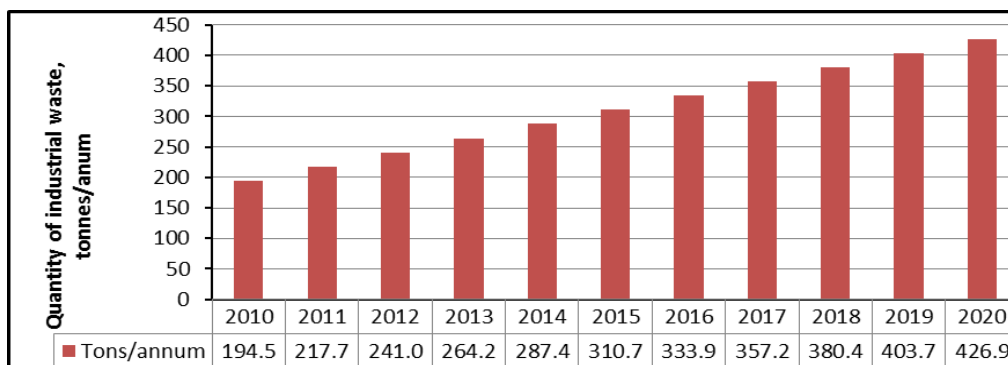


Fig. 4. Projection of industrial non-hazardous solid wastes in Addis Ababa.

d. Current industrial waste management practices

The collection of industrial waste is taken place by government and private solid waste collection and

transportation vehicles. As shown in figure 5, most of the organizations are using a car with sizes of 8 meter cube. The collection and transportation service delivering vehicles do not

have standards and safety prepared for the carrying hazardous industrial waste. They do not consider safety and precautionary measures.

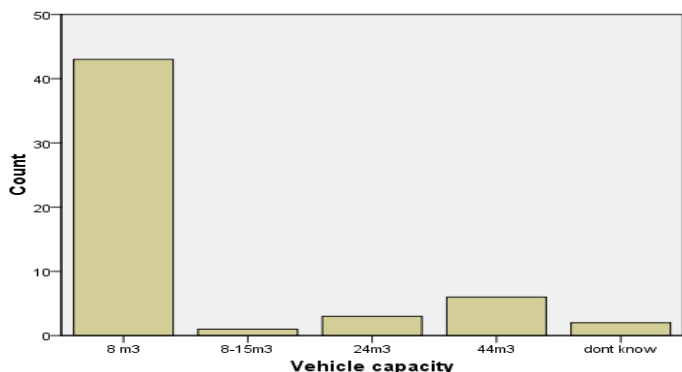


Fig. 5. Industrial waste collection vehicles.

It was also identified that most of the industrial hazardous waste generated in different industrial establishments are semi liquid. As it is shown in figure 6 the majority of hazardous waste is characterized as a semi liquid; which is a bi product of different processing units. This semi-liquid hazardous waste are collected and transported with the other non-hazardous waste part of the industries. End pipe treatment techniques will be applied for the liquid hazardous waste. However, the sludge hazardous waste remained after liquid waste treatment is transported to the landfill.

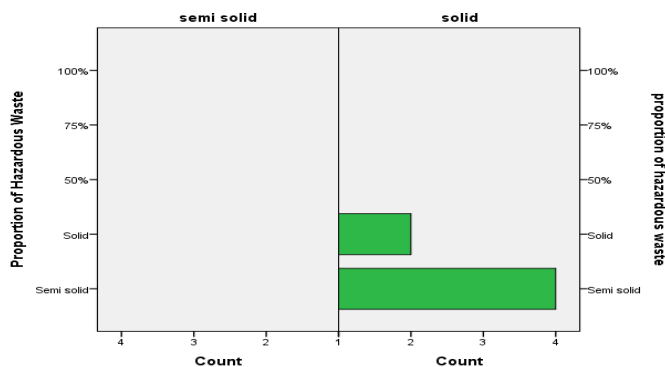


Fig. 6. Proportion of hazardous industrial waste.

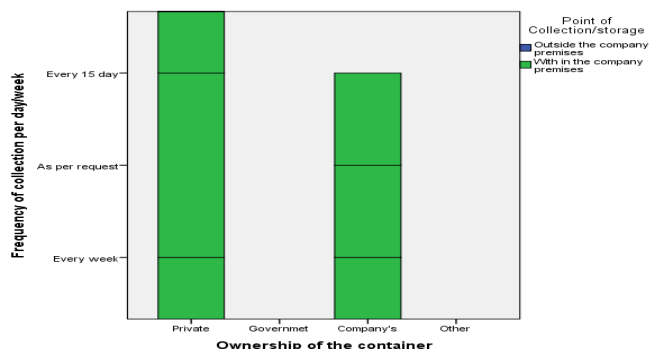


Fig. 7. Frequency of industrial waste collection.

As described in figure 7, most industrial establishment is getting an industrial waste collection activity as per the request

when the solid waste collection containers are getting full. The waste collection companies visits the industry one or two times per week. However, in some cases waste collection companies visit the industry with of request according to the contract type made.

#### IV. CONCLUSION

The management of hazardous waste in Addis Ababa requires increased attention to avoid the substantial adverse effect on human health and environment. There is no separate hazardous waste management system that was installed in the city. However, various category of hazardous waste are being collected, transported and disposed with other non-hazardous municipal solid waste under the action of municipality cleansing management agency.

Higher amount of hazardous waste are generated from various institutions. The per capita industrial hazardous waste generation rate in Addis Ababa is 290 kg/industry/day. About 348000 kg/day waste are generated from 1200 medium and large manufacturing industries. There is adequate segregation employed in the hazardous waste generating institutions to separate the hazardous waste from the non-hazardous part. However, there is no practice of waste segregation in the industrial establishment.

Incinerators are the common hazardous waste treatment technology employed in most industrial establishment. The review of Addis Ababa city hazardous waste management system depicted that the practices in most generators were found poor. This indicates that little effort has been made to adequately manage hazardous waste in the city. In most of the industries hotspot areas assessed in this study a waste was collected and transported in unsafe containers without the protocol of set by the WHO, ILO and UNEP/SBC.

Several challenges have been observed. Lack of physical resources, equipment, lack of clear responsibility for hazardous waste management, poor operating procedures for disposal of waste, lack of administrative priority and Shortage of training and subject awareness in the supporting and technical stuffs are few of the problems that needs attention from the government, public and other concerned organization. Lack of stakeholder partnership and integrated working modality was also one bottle neck to improve hazardous waste management. Lack of legal instrument in the hazardous waste management was also observed as one of the sectorial threat that should be revisited in the next time. Lack of well-organized private sector involvement is also a limitation for implementing better hazardous waste management system.

#### V. RECOMMENDATIONS

Even if there is good start of waste source segregation in the system should be strengthened for all medical organizations and need to be installed to the industrial waste management system. Intensive work need to be done to improve public and private awareness and participation in specific to industrial hazardous waste management.

A separate hazardous waste collection, transportation and treatment system need be installed to the city administration of

Addis Ababa to ensure the safety of environment and human health. Separate waste collection containers should be prepared and appropriate warning and descriptive label should be posted on it. Also isolated collection and transportation modality with a specifically assigned collection trucks need be established.

Establishing a sustainable financing mechanism for hazardous waste management should be installed and the service giving private waste collection organization earn comparative payment for the service.

A competing agency (Cleansing Management Agency or EPA) should emplace standards for the collection, transportation and treatment of hazardous waste generated from industrial establishment hotspots. The hazardous waste management guidelines and working procedures prepared by Cleansing Management agency should incorporate standards set by WHO and UNEP/SBC. Hazardous waste management should be institutionalized inside the waste management system of Addis Ababa City either in the cleansing management agency or recycling and disposal project office. Therefore, a separate hazardous waste management core process or department should be established. This process will regulate the private waste collection companies who are working on it, administer treatment centres and hazardous waste generators. Also, the department or core process checks compliancy of the management system against the set of standards on locally prepared guidelines or WHO/UNEP/SBC standards. Adequate trained human labour and budget should be allocated.

Establishing a standardized hazardous waste treatment plant is too expensive that cannot be addressed by single organization. Instead, the government should establish a centralized hazardous waste treatment centres in four corners of the city administration. The treatment centres should be designed and established in account of biomedical hazardous waste from industrial waste generated from different hotspot areas. The newly constructed sanitary landfill need to incorporate a hazardous waste disposal cell for residual hazardous waste brought from treatment centres and practice accordingly. Adequate training should be given for landfill practitioners to ensure their OSH. Recycling of industries should be started.

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