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Study of Hazardous Biomedical Waste Management Practices and Development of Hazardous biomedical Waste Management Guidelines in Addis Ababa

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Abstract— *The management of healthcare and other hazardous waste was of great importance to the welfare of the people and country at large due to its potential environmental hazards and public health risks. The waste produced in the course of health-care activities carries a higher potential for infection and injury. The World Health Organization has graded healthcare waste as the second most hazardous waste after radioactive waste. Addis Ababa, like other developing countries cities faces the problem of healthcare waste management. All these waste streams were 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 was conducted to assess hazardous waste management practice and design standard hazardous waste management guidelines. Health care institutions generation hotspot points were randomly sampled for data generation and collected data were analyzed to determine generation rates per health care institution (hospital, health center and Clinics) per person for biomedical waste. The data collection for determining hazardous waste generation rate has been conducted for seven consecutive days. Characterization study has been done by categorizing the wastes into infectious, noninfectious and sharp wastes. Questionnaire survey has been carried out to gather waste management practice of the institutions. The average biomedical waste generation of Addis Ababa city health care institutions was 465.17 kg/day for hospital, 15.61 kg/day for health centre and 8.88 kg/day for clinic. The survey indicated that composition of biomedical waste in hospitals was 33% infectious, 2% sharps and 65% non-infectious. The generation rate of biomedical waste in hospitals was 154.45, 10.72 and 300 kg/day for infectious, sharps and noninfectious waste respectively. The composition of biomedical waste in the health centers was found to be 30% infectious, 9% sharps and 61% noninfectious. And, the biomedical waste generation rate in the health center was 4.67, 1.47 and 9.47 kg/day for infectious, sharps and noninfectious waste respectively. However, the biomedical waste compositions in clinics were 21.2% infectious, 9.9% sharps and 68.9% noninfectious and about 1.88, 0.88 and 6.11 kg/clinic/day of infectious, sharps and noninfectious biomedical waste respectively was generated in Addis Ababa. Regarding hazardous waste management practices in the health care institutions hotspot areas, the survey shown that most of the hazardous wastes were not properly segregated and managed across all the three streams. The study showed that the hazardous and non-hazardous wastes were mixed together and disposed into the environment carelessly, with the exception of the Health care institution wastes which usually were incinerated. Collection service was being rendered by small and micro enterprises in the city. However there were no occupational safety and health issues addressed with the system. Used chemical containers were sorted/collected and sold to people for reuse and there was no records concerning how empty containers were handled. In most cases hazardous wastes from health care facilities and infectious 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 health care facilities that were regularly inspected do not meet the standard limit requirements set by the regulatory bodies. It also showed that there was no institutional system working on hazardous biomedical waste management system separately.*

I. INTRODUCTION

Addis Ababa, whose population grew from about 2.1 million in the year 1994 to 2.7 million in 2007, was one of the fastest growing cities in Africa. Its current population was estimated to be exceeding 3.1 million and now 2009 5 million and, apart from its sheer population size, the city was 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 was the Federal Capital, accounts for almost a quarter of the national urban population that was 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 was 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 were 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.

The core problem of Addis Ababa's solid waste management is the ever increasing generation of hazardous waste due to high rate of population growth, service sectors and increasing industrialization. Based on the 2007 national census report, by 2015 the population of the city is expected to increase 4-5 millions. Furthermore, currently, the City Administration estimates that at least one million people enter and leave the city on daily basis.

There are 48 hospitals, 88 health centres, 29 health posts, 847 clinics (private and non-governmental) and 109 pharmacies in Addis Ababa that were rendering health care services to the dwellers of the city. Table I below shows

population and distribution of these health care institutions across the ten subsidies of the Addis Ababa.

TABLE I. Health centers and clinics distribution in Addis Ababa

Sub cities	Population CSA (2007)	Health centres	Clinics
Lideta	255,372	7	34
Addis Ketema	181,270	8	57
Arada	211,501	8	83
Gullele	308,995	10	35
Nefas Silk	267,624	9	139
Bole	221,234	9	133
Yeka	428,895	11	88
Kirkos	201,713	7	74
Akaki Kality	316,283	8	71
Kolife Keraniyo	346,664	11	133
Total	2,739,551	88	847
Hospitals		48	

Source: Addis Ababa Food, Medicine & Healthcare Administration and Control Authority (AAFMHACA), 2016.

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 was 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 was 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 biomedical waste management system separated from the municipal/general waste management was a missing part as a crucial element to realize the safety of waste management workers, health of society and environment. There was no adequate information about hazardous biomedical solid waste characterization and generation to design proper way of management system. There was a lack of locally adapted standards and guidelines.

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

Hence, a study has been conducted to assess the characterization, generation and prevailing management practice of hazardous bimedical waste in Addis Ababa. The study has conducted on biomedical waste streams. Selected hazardous biomedical waste generators from potentially identified institutions/organizations of the three steams have been assessed for data collection. A waste generation and characterization including assessments of current management practice has been done for the biomedical waste. The profile data will be utilized for the development of hazardous biomedical waste management guideline.

II. METHODOLOGY

2.1 Description of Study Area

Addis Ababa was a capital city of Ethiopia with great geographical diversity endowed with rich natural and human resource base, and yet it was 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 was rural. It lied 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 were about 10^0C and 25^0C. 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 II below.

TABLE II. 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 [$P_n=P_o e^{(R/100)\,xt}$], where R is rate of population growth, t is time in years, p_o is initial population, p_n is final population and e is common logarithm.

However, there is no formal economic classification of urban duelers 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.

2.2 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 biomedical 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 biomedical 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 biomedical 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. The assessment conceptual framework is shown in Figure 1.

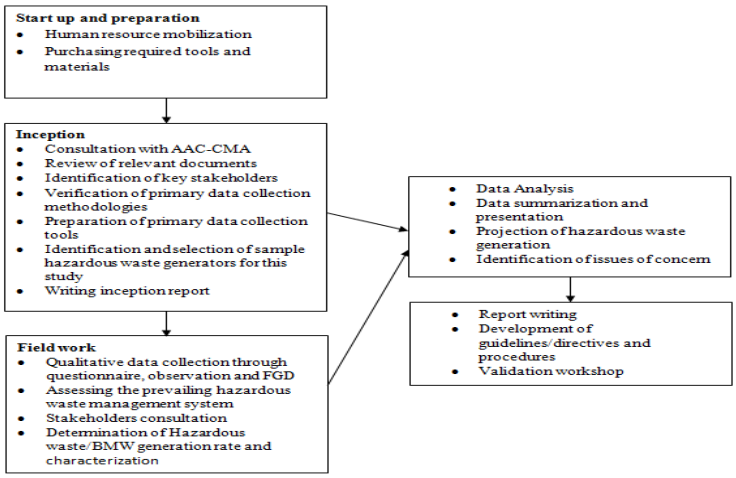

Fig. 1. Conceptual design of the methodology.

2.3 Types and Sources of Data Collection

a. Type of data

Both primary and secondary data were collected. Primary data were generated from 10 selected hospitals, 20 health centres and 60 clinics. 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 biomedical waste streams. As could be seen in table III, the stakeholders selected for data sources were from government and non-government sectors.

TABLE III. List of stakeholders.

Biomedical waste
AACMA and offices
AASRDPO
AAEPA
SMEs
Hospitals
Health centres
Clinics
Health biro
AAFMCA
Solid waste collection and transportation companies

2.4 Sampling Techniques

Both multi-layer purposive and systematic random sampling techniques were used to select sample health care institutions for data collection. Hospitals, health centres and clinics were identified and selected purposively based on the size of their services rendered. Systematic random sampling method was adapted to select hospital, clinics and health center for data collection.

A total number of 48 hospitals, 88 health centres and also 847 clinics were present in Addis Ababa (Addis Ababa health bur roué, 2016). Of these health care institutions 10 hospitals, 20 health centres and 60 clinics were selected for assessment of the biomedical waste management practices. The total number of these hospitals, clinics and health centres was determined from the whole population by using a scientifically proved sampling formula explained by Yamane

(1967:886)'s cited in (Boniface, 2014). Representative samples of healthcare institute were selected by considering 90% confidence level and 10% margin error.

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where: n is the sample size, N is the population size (Total number of health care institutions), e is the level of precision (= 0.1)

Accordingly, about 4 hospitals (1 from specialized, 1 from district, 1 regional and 2 private hospitals), 4 health centres (government) and 10 clinics (higher clinics) were selected for characterization and generation study. The sample distribution of these health care institutions are summarised in table IV below.

TABLE IV. Sample health care institutions.

Type of HC institution	Total population/number	Sample population/number
Hospitals	48	10
Health centres	88	20
Clinics	847	60
Total	1003	90

2.5 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. Each group contained at least two experts. Five of the groups were assigned to collect biomedical waste management practice from the selected 90 health care facilities.

The biomedical waste generation and composition data were collected from the selected sample health care institutions for eight consecutive days. All the generated, collected and stored health care waste in the health care institutions was cleared in the first day; then recording of the type and quantity of characterized waste was started in the second day and was continued for the consecutive seven days.

The generation rate expression 'kg/health care institution/day' was used. Since, the purpose of this study is generating information for planning to municipal operation; the term 'kg/health care institution/day' is easily adaptable and also a good expression as compared to kg/bed/day.

2.6 Hazardous biomedical Waste Generation and Characterization

Different approaches have been employed to characterize the three hazardous biomedical waste streams. Hazardous biomedical waste. However, biomedical waste generation was quantified using standard protocols by taking sample hospitals, health centres and clinics. The following preparations were made procedures that were followed to generate data from health care institutions were;

a. Appropriate tools and equipment which include;
   - Plastics and Polyethylene bags/biohazard plastic bags,
   - Weighing scale with an accuracy of 100g,
   - 16 sq. meter plastic sheet for characterization,
   - Safety wears,
   - Goggles,
   - Gloves,
   - Masks,
b. Standard OHS and data collection protocols,
c. Training and Awareness building to data collectors,
d. Preparing appropriate places, recording sheet/checklist and experts,
e. Correct procedures,
   - Tag the code of the sample site on the plastic bag,
   - Weigh and record the empty plastic bag,
   - Measure the weight of waste containing coded plastic,
   - Record on the data sheet to the correct code,
f. Timing of sampling
   - Sampling of the waste from the selected site was 24 hours system e.g. from 9:00 AM today to 9:00 AM tomorrow for every day of the 7 days.
g. Collecting and clearing the waste from the working place to the safe disposal place.

2.7 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

3.1 Biomedical Waste Management

The health management system of Ethiopian was categorized in to primary, secondary and tertiary level health care system. As shown in figure 3, primary health care service was being given by clinics/health post, health center and primary hospitals.

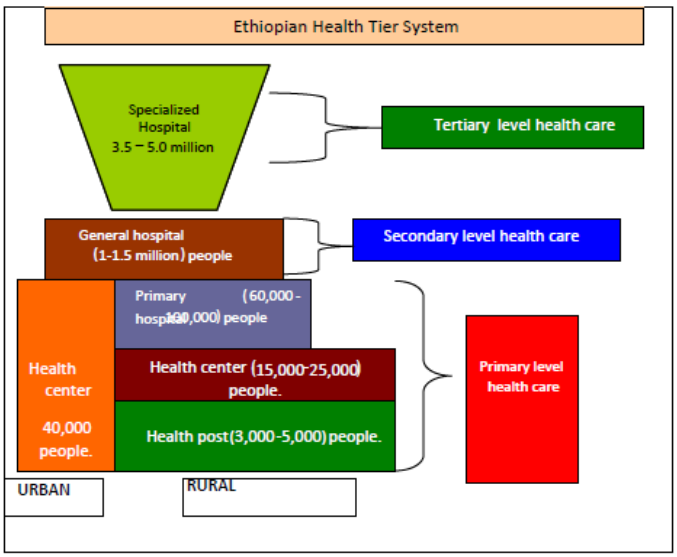

Fig. 2. Ethiopian health tier system.
Source: Ministry of Health (2015/16).

The health post, health center and primary hospital serve a population of 3000 –5000, 40000 and 60000 –10000 respectively. General hospitals serve secondary treatment for a population of 1 to 1.5 million people. The tertiary health care treatment was served by specialized hospital with population for 3.5 –5.0 million. So that a total number of 98 health centers, 847 clinics and 48 hospitals were present in Addis Ababa at present. The waste management system of these entire health care establishments was attributed to the scope of the service rendered and discussed below.

3.1.1 Per Capita Biomedical Waste Generation Rate

3.1.1.1 Health care facilities

A biomedical waste in Addis Ababa health care facilities was managed by through categorization in to infectious, sharps and non-infectious wastes. The average biomedical waste generation of Addis Ababa city health care facility was 465.17 kg/hospital/day for hospital, 15.61 kg/health center/day for health center and 8.88 kg/clinic/day for clinic.

The composition of infectious, sharps and non-infectious wastes in the total biomedical waste generated in the city are 33%, 2% and 65% for hospital, 30%, 9% and 61% for health centres and 21.2%, 9.9% and 68.9% for clinics respectively to infectious, sharps and non-infectious. A total of 300, 9.47 and 6.11 kg/health care facility/day of non-infectious waste was generated respectively with the hospital, health centres and clinics of Addis Ababa city; the rest of solid waste generated was sharps and infectious. So that the total hazardous waste generated in Addis Ababa health care facility was 165.16 kg/hospital/day, 6.14 kg/health center/day and 2.76 kg/clinic/day respectively. It showed that adequate segregation activity of non-infectious from the infectious waste was not well practiced across all the facilities.

As shown in plate 1 infectious waste was managed using a biohazard plastic bag and sharps were temporarily stored in a yellow safety box. Whereas non-infectious part of the waste was temporarily stored under a black collection bucket until it was transported and disposed in the open burning pit.

Plate 1. Biomedical waste in Addis Ababa health care facilities (infectious, Sharps/left to right/), April. 2016.

3.1.1.2 Hospital

The average per capita hazardous waste generation rate of hospital in Addis Ababa is 165 kg/hospital/day. The average generation rate of infectious, sharps and non-infectious wastes of hospital in Addis Ababa is 154.45, 10.72 and 300 kg/day respectively. The generation rate of infectious, sharps and non-infectious waste in the sampled hospitals are summarised in table V and figure 4 below. From a total number of sampled hospitals 7414.08, 514.56 and 14400 kg/day of infectious, sharp and non-infectious waste were being generated from Addis Ababa.

TABLE V. Hospital waste composition and characterization in Addis Ababa.

Hospitals	Infectious (kg/day)	Sharps (kg/day)	Noninfectious (kg/day)	Total infectious (kg/day)
Black lion	526.14	25.17	586.00	551.31
Hayat	4.86	4.43	7.71	9.29
Tirunesh Bejing	67.25	3.33	46.58	70.58
Alert	19.54	9.93	559.71	29.47
Mean	154.45	10.72	300.00	165.16
St. Dv	215.83	8.71	273.36	224.04

The composition of infectious part of biomedical waste was not greater than 15% (World Bank, 2012). A characterization study that was conducted in hospitals of Adola Woyu town in 2015 showed that 34.22% of the total hospital waste generated per day was infectious (Water aid Ethiopia, 2015).

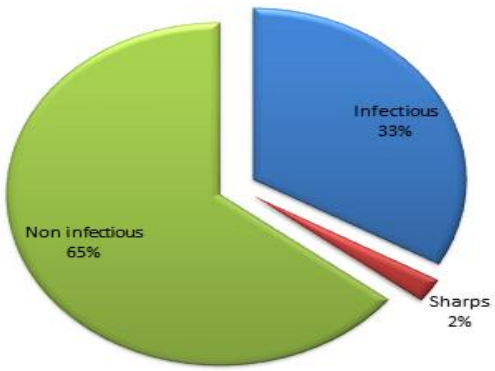

Fig. 3. Biomedical waste composition of hospitals in Addis Ababa (Kg/Hospital/Day), April 2016.

In this study the average amount of infectious hospital wastes in Addis Ababa was 33% of total waste generated in the institution (Figure 4). The other 2% was sharp and 65% is non-infectious waste. This showed that similar to other hospitals in the country source segregation of waste was not practiced adequately. Contamination of municipal part of the waste in the hospital increased the infectious waste composition.

3.1.1.3 Health Centre

Like hospitals, health centres in the city follows segregation of biomedical waste into infectious, sharps and non-infectious category. Yellow color safety box and red biohazards plastic bag were used for storing infectious and sharp wastes. Study in Adola health centres showed that 7.26 kg/day of waste was generated (Water aid Ethiopia, 2015). As shown in table VI and figure 5, a total waste generation rate 15.61 kg/day has been found in this study. By waste types; the average generation rate of infectious, sharps and non-infectious waste in Addis Ababa health centres are 4.67, 1.47 and 9.47 kg/day respectively.

TABLE VI. Biomedical waste generation rate of health centers in Addis Ababa; April 2016.

Health Centre	Infectious (kg/day)	Sharps (kg/day)	Non-infectious (kg/day)	Total infectious (kg/day)	Total waste generation (kg/day)
Zenebe work	3.46	1.27	16.00	4.70	20.70
Kality	9.07	2.00	10.29	11.07	21.36
Korea Zemachoch	2.14	0.43	2.62	2.66	5.28
Bole 17	5.36	1.10	12.14	6.46	18.60
Woreda 07 T/Hailmanot	3.31	2.53	6.29	5.84	12.13
Mean	4.67	1.47	9.47	6.14	15.61
St.dv	2.72	0.81	5.18	3.11	6.83

The relatively high volume waste generation of waste in the health centres were attributed to the number of customers/patients that were being served. The type of waste category that was being generated has showed the management practice of health centres. The comparative generation rate of biomedical waste according to its category is shown in Figure 5.

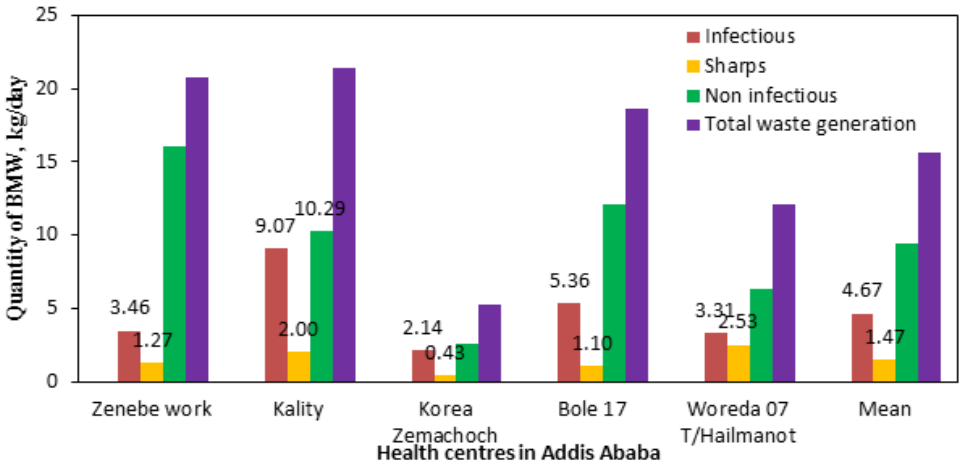

Fig. 5. Biomedical waste generation of health centers in Addis Ababa, Ethiopia, April, 2016.

A study in other parts of Ethiopia confirmed that about 38% of the health centre waste generated was infectious. As it was also observed in this study, the percentage of infectious waste in the health centre of Addis Ababa was 30%; it was extremely higher as compared to the international standards set by WB, which is 15-20%. Figure 6 below portrays biomedical waste characterization of health centre waste in Addis Ababa.

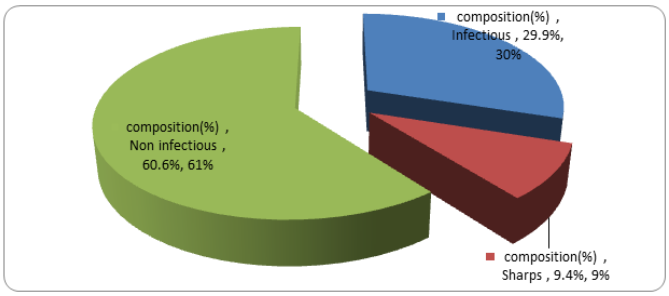

Fig. 6. Biomedical waste characterization of health center waste in Addis Ababa, April 2016.

3.1.1.4 Clinics

Like the hospitals and health centres, almost all clinics in the city follow segregation of biomedical waste into infectious, sharps and non-infectious category. Except in few clinics; the yellow colour safety box and red biohazards plastic bag were used for storing infectious and sharp wastes. As shown in table VII and figure 7, a total waste generation rate of 8.88kg/day has been found in this study. By waste types; the average generation rate of infectious, sharps and non-infectious waste in Addis Ababa health centres were 1.88, 0.88 and 6.11 kg/day respectively.

As shown in figure 7, the percentage of infectious waste in the clinics (21%) was slightly higher as compared to the international standards set by WB, from 15-20%. The other 10% and 69% of the waste were composed of sharps and non-hazardous waste. Source segregation of biomedical waste in clinics was slightly higher than in hospitals and health centres.

TABLE VII. Biomedical waste generation of clinics in Addis Ababa, April 2016.

Clinics	Infectious	Sharps	Non infectious	Total infectious	Total waste generation
Aynalem Higher Clinic	2.07	0.68	15.86	2.75	18.61
Yabets higher Clinic	1.50	0.96	16.14	2.46	18.61
Vision H.Clinic	2.60	0.89	1.11	3.49	4.60
22 mazoria higher clinic	3.00	2.64	9.50	5.64	15.14
Yalem Higher clinic	1.43	0.47	2.29	1.90	4.19
silasie higher clinic	1.14	0.38	1.07	1.52	2.59
Akaki higher clinic	1.86	0.54	1.64	2.39	4.04
Chechela higher clinic	1.45	0.51	1.29	1.96	3.24
Mean	1.88	0.88	6.11	2.76	8.88
st.dv	0.64	0.74	6.71	1.31	7.21

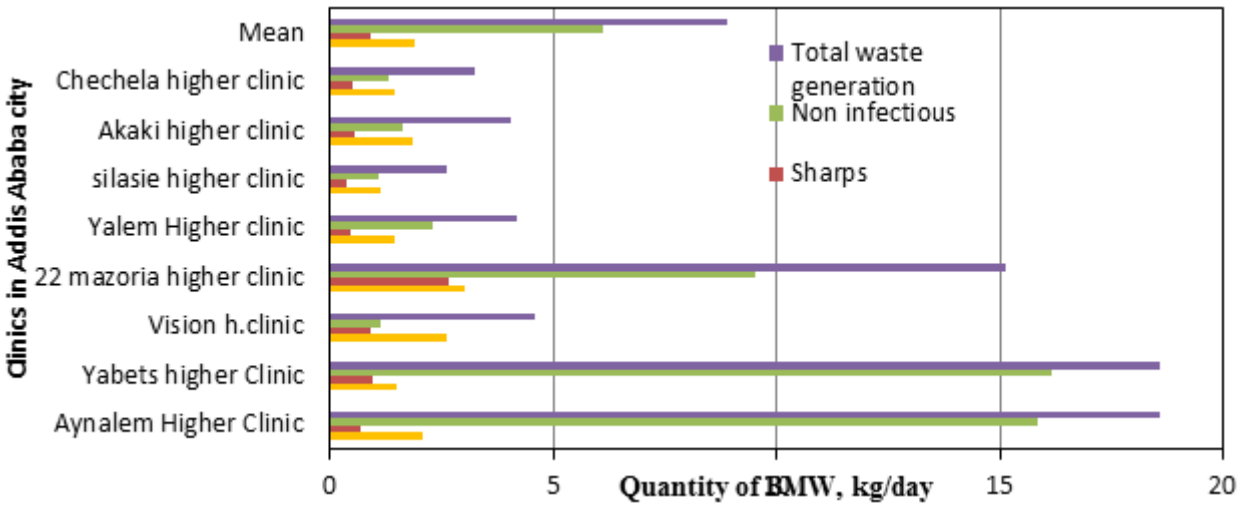

Fig. 7. Biomedical waste composition in clinics of Addis Ababa, April 2016.

3.1.2 Projection of per capita biomedical waste generation rate

Assuming that the health bureau of Addis Ababa and ministry of health establish a health care institutions based on their strategic plan proposed in the next five years and the rate will be continued uniformly for the next 5 years; the number of hospitals and health centres will reach to 51 and 98 respectively. The rate of growth in number of health centres will be grow uniformly in every year in account with the rate of population growth and rate of urbanization. Investment opportunity and privatization condition are a factor for predicting the growth of private health care institutions. There was no enough information to estimate the number of private hospitals and clinics in the future. But according to the Addis Ababa FMHCA estimation the city government works by focusing on the quality of service instead of increasing their number. Hence, the existing number was being taken for the next five years. The baseline information that was taken for prediction is described below.

- Derived daily biomedical waste generation for hospitals, health centers and clinics were 465.17 kg/hospital/day, 15.61 kg/health centre/day and 8.88 kg/clinic/day respectively.
- Now in 2016/17 there were 88 health centers in the city. Assuming that one health center will serve 40,000 populations; a total number of 98 health centers will be presented by 2020.
- It will be served a projected population of 3,599,003 at 2020 with national urban population growth rate of 2.1% (CSA, 2007).
- The number of private hospitals will be kept constant. But the number of government hospitals will be increased by 3 and will reach 51 in 2020.

3.1.2.1 Health centers

According to the projection of health center to 40,000 population principle, a total number of 98 health centers will be presented in Addis Ababa by 2020. By assuming the working as usual scenarios of the prevailing health center waste management system 1513.4 kg/day of infectious, 708.4 kg/day of sharp waste and 4918.11 kg/day of noninfectious waste will be expected in 2020.

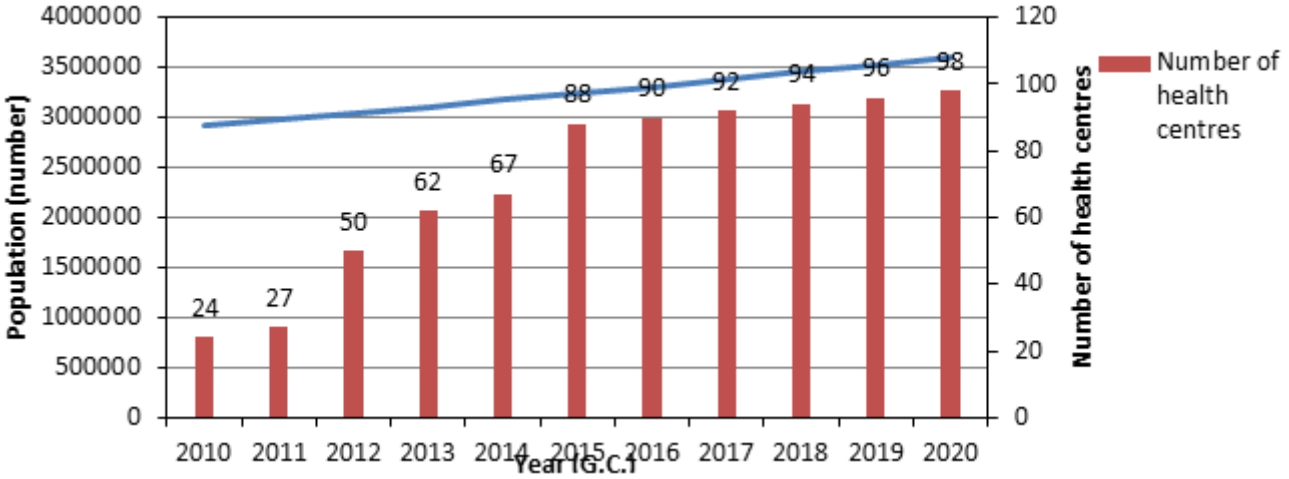

Fig. 8. Trends of population and health centers coverage growth in Addis Ababa, April 2016.

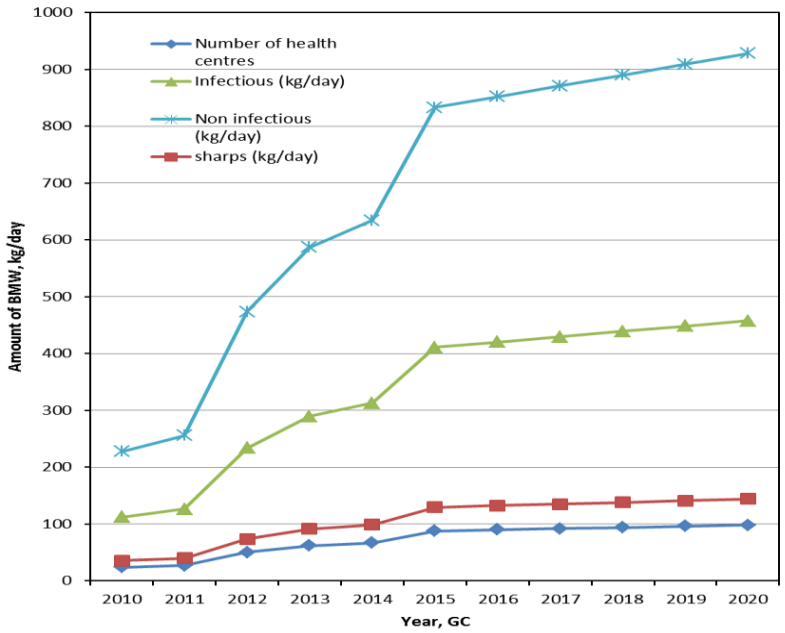

Fig. 9. Biomedical waste generation trends of health centers in Addis Ababa

3.1.2.1 Hospitals

Only one hospital called Tirunesh Beijing has been constructed in the history 40 years of Addis Ababa city growth. According to the information taken from Addis Ababa health bureau 2014/15 annual bulletin the hospital was constructed in 2004 using the development collaboration of China government and registered as the 6th general hospital of Addis Ababa. Also the city administration has put three foundation stones to construct hospitals in three sub cities (Bole, Nefas silk and Kolfe Keraniyo). The city focuses on quality of the health care service and prevention rather than the expansion of health care institutions. However there was no concrete data that indicate future number of private hospitals and its growth was assumed to be kept constant. Also, there is no data which show federal government plan for the future expansion of number of hospitals. Instead of increasing number of health care institutions to cure patients, federal health policy works on prevention approach. Hence, there will no additional hospitals in the coming years. Therefore, only of 51 private, federal and regional hospitals will be presented in Addis Ababa in the next 5 years.

Assuming that the rate of per institution biomedical waste generation will not be affected by different factors; the total biomedical waste generated in the city of Addis Ababa will reach 23723.67 kg/day by 2020.

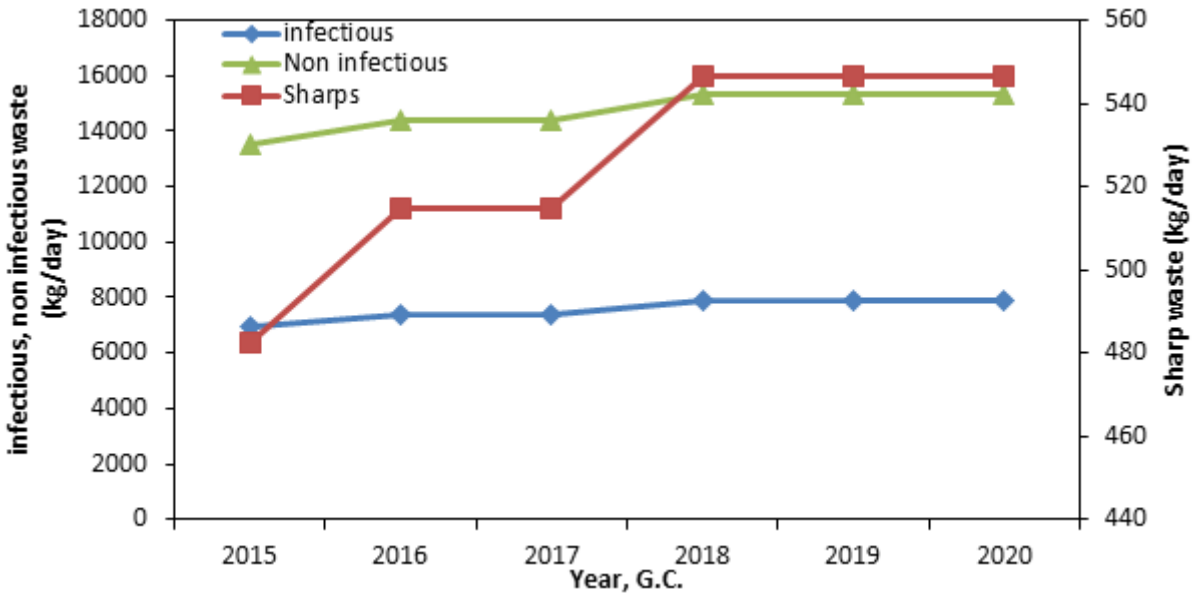

Fig. 10. Projection of biomedical waste generation in hospitals for Addis Ababa, Kg/Day.

3.1.2.3 Clinics

According to the city administration health bureau and FMHACA the quality of health care service delivery will be focused. The authority stresses monitoring of the present private health care institutions and improves the quality of their service. The key informant interview made with the city health bureau officials revealed that the growth in number of private health care institutions will not be prioritized. Even, the level of some of the clinics was reduced from higher to medium clinic level. So that increasing the number of clinics in the near future was very minimal. Hence, the current number of clinics was taken for projecting the biomedical waste amount in the next five years. Accordingly, by 2020; about 1513.4 kg/day, 708.4 kg/day and 4918.11 kg/day of infectious, sharps and noninfectious waste will be generated respectively.

Projection of biomedical waste generation

It was summarized that a total number of 51 hospitals, 847 clinics and 98 health centers were considered for a population of 3,599,003 people in 2020. As illustrated in table VIII below, a total of 9848.01 kg/day infectious waste, 2184.18kg/day sharp waste and 21146.17 kg/day nonhazardous biomedical waste will be generated in Addis Ababa in year 2020.

TABLE VIII. Projected biomedical waste generation in Addis Ababa, April 2016.

Year (G.C.)	infectious (kg/day)	Sharps (kg/day)	Non infectious (kg/day)	Total Biomedical waste (kg/day)
2015	8874.61	2024.16	19251.47	30150.24
2016	9347.3	2075.26	20170.41	31592.97
2017	9356.64	2094.2	20189.35	31640.19
2018	9829.33	2145.3	21108.29	33082.92
2019	9838.67	2164.24	21127.23	33130.14
2020	9848.01	2184.18	21146.17	33178.36

3.1.3 Existing biomedical waste management practices

The storage, offsite/onsite transportation, treatment and onsite/offsite disposal techniques of all health centers and clinics were almost similar. But there was a difference in the case of hospitals. Few hospitals such as Tirunesh Beijing hospital have better awareness and implementation of better technologies. Even if there was better technology employed in some of them segregation of biomedical waste according to its behavior was not practiced. However in few of the hospital there is low awareness and improper working conditions. They were collecting mixed wastes and transport to the municipal solid waste container without any pretreatment. Biomedical waste management system of Addis Ababa city was presented in the subsequent sections in detail based on type of technology and infrastructure employed administrative organizational structures, stakeholder and public participation, financing mechanisms, regulations and enforcement.

3.1.3.1 Onsite storage and collection

Addis Ababa city administration has a primary and secondary mixed solid waste collection system. However the City Administration Cleansing Management Agency has no separate hazardous biomedical waste collection, transportation and disposal systems and technologies. The biomedical waste in hospitals was stored in Black, yellow and red primary storage containers (Plate 2). It was being transported inside the health care institutions by using wheel barrow and wheel mounted coloured containers. Most of the health centres and hospitals practiced this onsite storage and transportation system. However clinics did not practice segregation of biomedical waste using colour coded plastics. They used hard cartons or buckets instead of standard waste collection bin.

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Plate 2. Onsite biomedical waste storage bin (infectious, sharps and non-infectious from left to right).

3.1.3.2 Treatment

The treatment technologies used by the hospitals, health centres and clinics include: incineration, irradiation, sterilization and chemical disinfection. Except few government and private hospitals like Black lion, Minilik, Tirunesh Bejieng, Hayat and St. Gabriel hospitals most of the institutions did not use a high quality multiple hearth incinerator at a temperature above 1200°C. Instead they are using single chamber-local brick incinerator for treating infectious and sharp wastes.

Most health centres and hospitals in Addis Ababa have a brick incinerator (plate 3) that serves to treat infectious and sharp waste treatment before disposal. The chimney of most incinerator was too short that will be brought complains from the nearby radius residents. It was also a single hearth incinerator that doesn't have enough temperature to decompose the flue gasses pollutants and killed thermo resistance pathogens. All government health centres have incinerator with similar design (Plate 3). Hospitals have different incinerator design and types.

Tirunesh Bejing has standardized incinerator (Plate 2/left) that can treat 117.16 kg/day of biomedical waste per day. St. Gebriel and Hayat Hospitals from the private health care institution use standardized class of incinerator (Plate 2/middle). Most private clinics have no biomedical waste treatment technologies. They commonly use mixed collection of the waste with the municipal residential waste that were being collected and transported by the city administration and some of them use half sand filled panel or oven like incinerator. According to the discussion made with Addis Ababa Health bureau; the clean and safe health facility will be ensured in the budget year. The ministry of health has developed a CASH (Clean and Safe Health Facility Audit) tool. Accordingly Addis Ababa health office has prepared its own strategy and implemented on hospitals and health centres. A continues inspection of health facilities and monthly CASH activity reporting were being done. According to the health bureau one central incinerator has been planned to be constructed in the next budget year. Addis Ababa FMHCA was also doing its best to ensure the sanitation and hygiene of health facilities.

Plate 3. Incinerator at the health center, private hospital and government hospital (from left to right).

3.1.3.3 Offsite collection and transportation

The offsite transportation of biomedical waste in Addis Ababa was unsafe. Most of it was transported to city unsafe waste disposal site. Private waste collection companies collect the waste from the private and government hospitals using municipal waste collection trucks without taking care. The

offsite transportation system pollutes the outside environment as well as landfill surrounding. There was no precaution for the workers and it did not follow the international working protocols set by WHO and ILO.

As it was shown in table 18, an average of about 3337.18 kg/day of health care waste was collected from different hospitals and used to be transported to disposal site by private waste collection companies during the year 2014. There was no separate waste collection vehicle assigned to biomedical waste management services. The private companies used similar type of vehicle for both biomedical and municipal waste collection and transportation services. There was no specific label used to separate the hazardous biomedical waste collection from the others.

TABLE 1. Mean (Monthly and daily) amount of biomedical waste collected and transported to the landfill, April 2015.

Hospitals	July /2014	Aug/2014	Sep/2014	Oct/2014	Nov/2014	Mean collection amount of BMW, kg/month	Mean BMW collection amount (kg/day)
Pawlos	21120	15840	15840	21120	15840	17952	598.4
Kkkkkkj bbb /	0	2640	2640	0	2640	2640	88
Polis	0	5280	5280	10560	2640	5940	198
Gandi	7920	5280	5280	5280	10560	6864	228.8
Blacklion	29040	29040	42240	31680	31680	32736	1091.2
D.Minilik	2640	5280	2640	2640	2640	3168	105.6
Balcha A.	5280	7920	7920	7920	7920	7392	246.4
Amanuel	0	4620	2310	2640	2640	3052.5	101.75
Alert	5280	2640	5280	5280	7920	5280	176
Yekatit	7920	7920	5280	5280	10560	7392	246.4
Yared	0	0	0	0	2640	2640	88
Addis general	0	0	1980	2640	2640	2418.9	80.63
Haleluyaki	0	0	2640	2640	2640	2640	88
Sum of BMW collected by cleansing management agency						100115	3337.18

Source: CGA-CMA, 2014

3.1.3.4 Disposal

Pit system was a commonly used onsite disposal system; The Placenta and other pathological wastes of the hospital were disposed into a specifically prepared placenta pit, and then a chemical treatment like pouring sodium Hydroxide will be followed to prevent bad odor and facilitates combustion.

In this study it was found that all hospitals and health centres used the placenta pit to dispose the pathological/anatomical waste. Even the ash remained after the incineration activity were either transported to the landfill or disposed of at the ash pit. But the ash pit in few hospitals was not well built enough to guaranty protection of ground water pollution. While pharmaceutical wastes were disposed under the mandate of FMHACA. But there was no defined disposal site for drugs and pharmaceutical waste rather it was selected by the waste generator. All the health facilities used municipality waste management service to transport the non-hazardous waste from their premises. Regardless of strict rule of radioactive waste management /storage, collection, transportation and disposal methods set by WHO, none of the hospitals, health centres and clinics have concerned on the radioactive waste produced in their premises.

Plate 4. Common placenta pit system in Addis Ababa health care institutions, April 2016.

As shown in Plate 3, the pit construction practice did not meet the WHO standard that was enough to leakage of leachates downwards and horizontally. However, it was used to be transported and disposed in the open dump site of Addis Ababa city without taking care of the adverse impact.

3.1.3.5 Recycling

There was no practice of recovery of materials (recycling) from the biomedical waste stream of Addis Ababa city health care facilities. Even if more than 85% of the solid waste in the health care facility was non-hazardous and easily recyclable; due to poor source segregation practice recycling was almost nil. As it was confirmed by 97% of the respondent there was no adequate practice of solid waste recycling in Addis Ababa health care institutions. However some respondents have experience of reusing materials like plastic bags, hard paper/ 'carton', paper and some plastic containers by bringing to their home.

3.1.3.6 Public and stakeholder awareness and participation

In this study it was found that all health care facilities have awareness on biomedical waste management at institution level. However, there was a limitation at the employ level. The awareness of employees was limited and they were not practicing the safe working protocols and procedures. Almost all hospitals have no protocol manuals and regular training for their employees. As a result of a push from the ministry of health and Addis Ababa health bureau most health centres, hospitals and clinics started movement to achieve a clean and safe working environment.

Government structures showed that there was a task and mandate division among stakeholders EPA, CMA and FMHACA on hazardous biomedical waste management. The regulatory part for environmental protection section was being done by Environmental Protection of Addis Ababa, the municipal waste management operation was being done by cleansing management agency and the sanitation and hygiene knowledge, attitude and practice improvement was taken over by Addis Ababa health bureau and Addis Ababa FMHACA. The key informant interview made in Addis Ababa health burro and secondary data collected from the same office indicated that the health burro was working to improve the waste management system of health care facilities by designing CASH and establish IP department. The collaboration with cleansing management agency and AAEPA would be a success for CASH achievement. In conclusion to the finding of this study there was no formal work partnership with the public, health facility owner, relevant government offices (AAEPA, AAHB & AAFMHACA) and privates on hazardous biomedical waste management.

3.1.3.7 Institutional framework

It was found that the collection, transportation, treatment and disposal of biomedical waste in Addis Ababa have no owner. Like other municipal (non-hazardous) waste it was being done by municipality. There was no organizational structure at the city level that was responsible only for biomedical or hazardous waste management. According to the study finding in government hospitals there was a team organized from different department called infectious protection team. The committee members were being coordinated by environmental health department. Regular awareness creation workshop was being organized by this team. Regular monitoring including administration of the premises waste management system was organized by IP department of the hospital.

3.1.3.8 Financing

There was no separate finance that was collected for biomedical waste management. Instead, the system was getting the cost of management by a monthly sanitation fee collected through water bill. The hospitals, health centres and clinics pay 42.5% of the cost of their water consumption payment through bill to Addis Ababa city administration cleansing management; then cleansing management agency give a waste collection, transportation and disposal service back to the hospitals. However, the service fee collected through water bill did not include the onsite treatment and disposal.

3.1.3.9 Privatization

As it was seen in other countries privatization was vital to waste management. The government can play as a regulating role if it outsources the service. Biomedical waste can be outsourced in a number of options. The collection and transportation service, treatment or/and disposal service or as a whole management system might be outsourced. However, it was being collected, transported and disposed with the other municipal wastes. Several private companies were collecting and transporting of biomedical waste by a commission given by Addis Ababa cleansing management agency. But the commission offered by cleansing management agency did not account the hazardous nature of the waste that were being collected and transported. Also there were no standards that regulate the private biomedical waste collection and transportation services.

3.1.3.10 Policy and regulatory framework direction

The international articles, regulations, strategies, policies and enforcement practices reviewed in this study showed that biomedical waste was one of the hazardous waste streams generated in the urban setting that needs a government special attention. The country ratified several hazardous waste conventions. Accordingly, the national government of Ethiopia incorporate the issue in different parts of regulatory documents from policy level to standard guidelines. But none of them talks about the standard procedures of biomedical waste management.

The available relevant regulatory document at international and national level for biomedical waste are Basel convention of hazards waste management, Bamako convention on hazardous wastes, EFDRE environmental policy article 3:7, Addis Ababa solid waste management policy, Environmental Pollution Control Proclamation No. 300/2002 Reduction and/or Elimination of Hazardous Waste Generation, Proclamation of FMHACA establishment, Proc No. 299-2002 Environmental Impact Assessment, Proc No. 295-2002 Environmental Protection organs Establishment, Regulation no.13/96 Addis Ababa city solid waste management and disposal regulation. None of the proclamations, regulations

and legal articles talks about biomedical waste source separation, treatment and safe disposal. Despite of all the policy and legal supportive tools, there is no standard working procedures and protocols prepared in Addis Ababa city administration. None of the health care institutions develop its own biomedical waste management guidelines except implementing the management option what is given from Addis Ababa health bureau or MOH.

IV. Conclusion

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

Higher amount of hazardous biomedical waste were generated from various institutions. A total amount of 31223.2 kg/day of health care waste were generated in Addis Ababa city. A total of 48 hospitals, 88 health centres and 847 clinics were present in the city. About 10,806.2 kg/day of biomedical hazardous waste was generated daily from Addis Ababa city.

There was adequate segregation employed in the hazardous biomedical waste generating institutions to separate the hazardous waste from the non-hazardous part. As to the medical organization biomedical waste was being sorted according to three categories. It was being sorted into infectious, non-infectious and sharps waste. Sharps and infectious waste categories are hazardous so that special management system was being emplaced. Incinerators were the common hazardous waste treatment technology employed in most health care facilities. Incinerator provides an interim solution especially for developing countries like Ethiopia where options of waste disposal such as autoclave, shredder or microwave are limited. However, most of the companies used substandard incinerators. The HCFs employed waste treatment methods using multiple hearth incinerators, incineration with low combustion, single-chamber, brick incinerators and open burning, which release emissions that are potentially hazardous biomedical to the environment and human health. It was also observed that some medical organization like St. Gebrie, Hayat, Trinesh Bejing and Blacklion hospitals were using better incinerator standards that can catalyse the flue gas from burning waste and also that contained higher temperature enough to decompose chemicals and pathogens to harmless compounds. In some HCFs Anatomical waste was disposed in an unethical manner. 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 health care facilities 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 biomedical waste management. Lack of legal instrument in the hazardous biomedical 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 biomedical waste management system.

V. Recommendations

Even if there was good start of waste source segregation in the biomedical management using colour coded plastic bag or colour coded temporary storage container; the system should be strengthened for all medical organizations. Intensive work need to be done to improve public and private awareness and participation in specific to biomedical hazardous waste management.

All stakeholders of hazardous biomedical waste management should be identified. Mandates of all the stakes need be clarified and boundaries been sectors should be done. A collaboration memorandum of understanding need be prepared and signed. Collaboration between them (e.g. EPA, CMA, HB, FHMCA, health care facilities/hospital/health centres/clinics) should be strengthening.

A separate hazardous biomedical 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 biomedical 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 medical organizations. 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 private and government clinics, health centres and hospitals 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 non-hazardous biomedical waste should be started.

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