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Solid waste management and its problem in Asmara city of Eritrea

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Md. Minhajul Hoda*[1]
minhajulhoda@rediffmail.com

Masihullah Khan*[2]
khanmassihulla@gmail.com

***Mahatma Jyotiba Phule Rohilkhand University, Gandhi Faiz-E-Aam College, Faculty of Social Sciences, Department of Geography, Shahjahanpur, India**

Abstract
Urbanization, rising incomes, and lifestyle changes are major drivers of municipal solid waste generation, especially in developing countries. Asmara, Eritrea, faces significant waste management challenges, particularly due to a large, disorganized open dumping site at Betghiorghish. This site lacks a proper recycling strategy and threatens local biodiversity. A study was conducted to evaluate the types and amounts of waste generated in Asmara, using primary data collected from various economic groups through questionnaires. Study found a positive correlation between urbanization and waste generation. Moreover, different economic strata have different amount and nature of waste. There is report of increasing amount of non-biodegradable waste among the higher income people/region. An integrated sustainable planning is needed to manage the municipal waste.

Keywords
Solid waste, developing countries, Asmara city, dumping site, waste management, municipal garbage

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Izvleček
Upravljanje s komunalnimi odpadki in z njimi povezane težave v Asmari, Eritreja
Urbanizacija, višji dohodki in spremembe življenjskega sloga so glavni dejavniki nastajanja trdnih komunalnih odpadkov v državah v razvoju. Asmara v Eritreji se sooča z velikimi izzivi glede ravnanja z odpadki, zlasti zaradi velikega, neurejenega odprtega odlagališča v Betghiorghishu, s čimer ogroža lokalno biotsko raznovrstnost. Študija, ki je obravnavala vrste in količine odpadkov na podlagi podatkov iz vprašalnikov, je pokazala pozitivno povezavo med urbanizacijo in nastajanjem odpadkov. Študija je pokazala, da obstaja pozitivna povezava med urbanizacijo in nastajanjem odpadkov. Poleg tega imajo različni gospodarski sloji različno količino in naravo odpadkov. Obstajajo poročila o vse večji količini biološko nerazgradljivih odpadkov med ljudmi/regijami z višjimi dohodki. Za ravnanje s komunalnimi odpadki je potrebno celostno trajnostno načrtovanje.

Ključne besede
Komunalni odpadki, države v razvoju, Asmara, odlagališče, upravljanje odpadkov, mestni odpadki

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1 Introduction

Solid waste management (SWM) is very acute and intricate problem in the cities of developing economies due rapid urbanization, increasing purchasing power, and changing life habits of the people (Gour and Singh 2023; Minghua et al., 2009). The solid waste management became more challenging in recent years due to tremendous increase in the share of the inorganic constituents in the wastes (Khajuria et al., 2011; Bhoyar et al., 2014). Developing states have meagre budget for waste management and the major portion of its budget goes to collection and transportation rather than their treatment and sustainable disposal (Mansoor et al., 2005; Burntley, 2007). That is why over a period of time waste management becomes a serious problem in many countries of the developing economy (World Bank, 2012).

There is evidence of mountains of hazardous and plastic wastes deposited in and around the cities of developing world (Shivji, 2023). One of the best examples a big dumping site on the outskirts Asmara city (Eritrea Green Energy and Waste Recovery EGEWR, 2011). Municipal Corporation is the sole major body to manage solid waste from source of origin to the disposal sites in Asmara city of the State of Eritrea. Municipal body usually collects waste through the two different methods i.e., curbside (house-to-house) collection method and the second one wastes in bulk waste collection containers. The solid wastes generated from each household and collection sites are collected in small containers, sacks and cans before it reaches to the final disposal sites (EGEWR, 2011).

Solid waste- includes from household preparation, cooking and serving of food; market refuses handling, storage and sales of product and meals etc. Non-biodegradable solid waste or rubbish (plastics, rubber, metal, glass, ceramics etc.) is also generated from different sectors of economy and services (Kiyan and Ikizoglu, 2020). There is lack of awareness and policy challenges in its management in Eritrea. Usually municipal garbage-wastes are mixed together become hazardous after its disposal to the dumping sites and nearby regions when there is no mechanism of proper waste management in greater Asmara region of Eritrea. Asmara city region is expanding fast due to increase in diverse economic activities and high rate of urbanization in recent years. Therefore, solid waste management becomes major challenges for the municipal body.

Municipal solid waste disposal created serious threats to both flora and fauna nearby low-lying regions close to the dumping sites (Abubakar et al. 2022). There is report of contamination of soil and water in and around greater Asmara region (Mihretab & Taibao 2018). Waste/garbage and their related problems intensify during rainy season when heavy rainfall cause washing and mixing of these wastes in it and spread nearby region. This problem become more acute due to its altitude as most of the nearby regions around greater Asmara is low-lying areas. Thus, when solid waste is being mix with the rainwater and percolate nearby region contaminates forested-land, water and soils. Various methods like land-filling, incineration and composting have been used for waste management, but none of them fully satisfy the increasing amount of municipal waste and their management in the city (Asmerom, 2021). Therefore, solid wastes are dumped at dumping sites in various locations around the city.

The bulk container collection sites are not also properly prepared in the city region. Most of them are not designed to protect the dispersal or removal of wastes by wild

animal, wind, rain or children. They have no foundation or basement and fence at the collection sites except a hospital in the Dembe Sembel complex of the Asmara city. The amount of the solid waste collection is increasing from year to year when it is compared to the previous year which is 7757 thousand tones in 2007 to reach 16,548 thousand tone in 2017(Maekel administration, 2018). The increase in the dumped waste is mainly due to the expansion of the city and population growth, increasing income, change in the urban lifestyle etc. Other key determinants in the increasing amount of waste include changes in economic structure– as well as demographic profile of the population (Nguyen et al., 2020; Khan, 2023).

Asmara city is experiencing unprecedented growth in recent years due to post independence reforms and developmental schemes initiated by the government of the State of Eritrea (Tekle and Ogba, 2008). In recent years large urban infrastructural developmental projects along with the improvement in living standard have severe impact on the nature and types of waste generation in the city. The limitation of public awareness along with the increasing amount of non-biodegradable material in the municipal wastes poses a challenge for the environmentally sound management of MSW (Pandey, 2024). Eritrea has the limited waste treatment and recycling services. This micro research will try to examine nature and types of waste generation and their disposal and management in the Asmara city with the following objectives:

1. To assess the amount and nature of waste generation in different regions of Asmara city.
2. To examine the kind and mechanisms of solid wastes management practices in the study region.
3. To identify the problems and difficulties of solid waste management in the city and suggests remedial measures for effective and sustainable waste management.

Profile of the Asmara City

Asmara was made the capital city of colonial Eritrea in preference to Massawa Governor Martini in 1897. Asmara is by far the largest city in Eritrea, with the estimated population of 0.8 million (EENI Global Business School n.d.). From administrative point of view the study region have been divided into thirteen local sub zone administrations normally known as Local Area Administration (LAA). It is located at the top of Eritrean highlands on the eastern edge of the escarpment with an elevation of 2350 meters above sea level. The city is located in 15° 17´N latitude and 38° 55´E longitude. The mean maximum and minimum temperature reaches 23°C and less than 10°C respectively (MOA, Asmara 2016) with a mean annual temperature of 15.6° C. All nine ethnic groups of Eritrea lives in Asmara city and among them, majority are from Tigrinya Ethnic group (Pool, 1980).

Asmara was developed from the union of four villages (Arbaete-Asmara) that took place during 12th century (Jan & Zölzer, 2012). Most of central Asmara was built between 1935 and 1945 during Italian colonial period. The city has been regarded as "new Rome" or "Italy's African city" due to its quintessential Italian touch, architecture, wide-streets, piazzas and coffee bars (Italian Asmara, 2018).

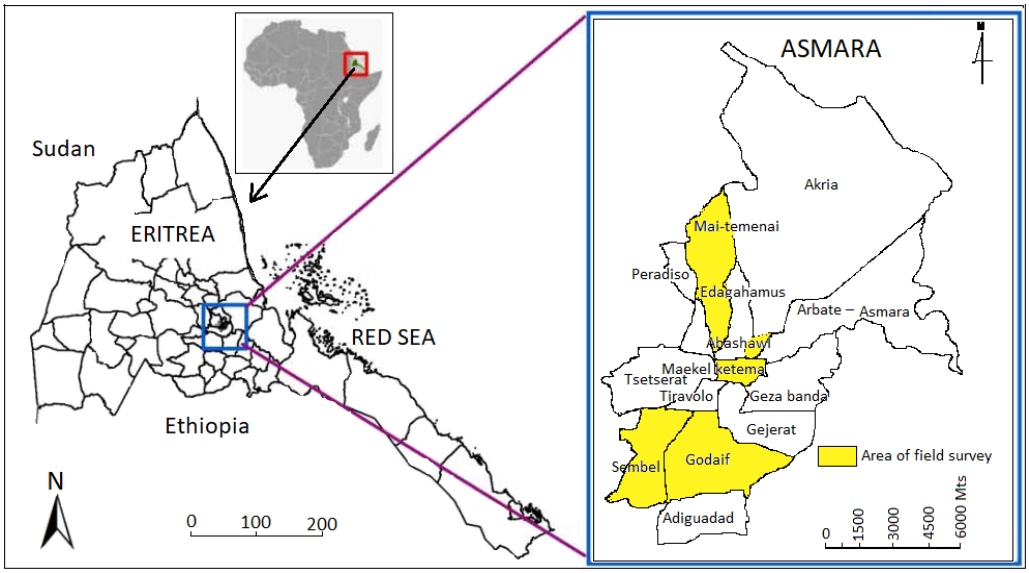

Figure 1: Eritrea (Asmara).
Source: MoLWE, Department of Land, 2018; EMIC, 2018.

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Background of Asmara Solid Waste Management (SWM)

Asmara cleaning and sanitation unit work under Zoba Maekel Administration. In the past, the sanitation unit was working under Italian government by Naschit, Anenima Company on the contract basis. The dumping sites for the waste disposal have changes with the evolution and growth of city.

- 1st- from 1930-1933, waste dumping state was in Edaga humus.
- 2nd-from 1934-1941, waste dumping site was in the area behind today's sanitation unit and Garage office.
- 3rd –from 1941 onwards, the dumping site changed to Adi-Abeito.
- 4th –in 1946, the dumping site changed by British government from Adi-Abeito in to the today's dumping site (Scarico) Betghiorghish for about 78 years and still it is working.
- 5th–sanitation of Asmara at the time of Hailesilasie regime was believed to be very clean and satisfactory.
- 6th –at the time of Derg regime in Eritrea (after 1974), sanitation of Asmara was in a bad condition due to Carelessness and lack of sanitation Equipment. After independence, with the expansion of Asmara and its population increase (urbanization), the government brought additional manpower, machineries, waste carrying trucks, waste compressor trucks etc. were bought to improve the sanitation of the city and its nearby areas. But with increase in population of Asmara and its expansion, lack of waste disposal equipment and others, the sanitation of the city is not fully under control.

2 Methodology

The present study is based upon primary and secondary sources of information. Secondary data have been generated from the sanitary unit of Municipality of Asmara, Ministry of land and environment, Maekel administration, documents, archives, internet and books.

Primary data have been collected from five administrative regions (LAA-Local Administrative Area) of Asmara city out of total thirteen municipal administrative regions. The five municipal areas were purposely selected based on distribution of large number of houses (different social and economic categories), business activities, slaughter houses, hospitals, restaurants and population size and their nature.

Three tier field survey have been conducted i.e., at firsts level household survey from local administrative area, second level municipal workers were interviewed and at third level different institutions of the Asmara city- such as factory, hospitals, and restaurant etc., to get the clear status of waste generation from Asmara city and their final disposal.

At first level from each administrative area of Asmara city-total 50 households randomly selected for interview. Thus total 250 sampled households were selected from all five sampled local administrative area of Asmara city. Second level 50 municipal workers' have been identified in order to answer the questionnaires who are engaged in the collection, transportation, disposal and management of wastes in Asmara city. And third level surveys were conducted from restaurants, hospitals, colleges, factories, slaughterhouses to assess the role of different sectors in waste generating and their management.

Survey data collected from questionnaire were processed into simple table format using Microsoft Excel Sheet. Further bar graph and table of data were prepared to show the result of field observation. Moreover, location distribution maps of waste generation were prepared with the help of QGIS and Microsoft Paint.

3 Results

3.1 Methods and nature of Solid Waste Disposal SWD

Waste generation methods in Asmara city usually go through primary collection, secondary collection, processing and finally disposed to dumping sites. Asmara is one of the first African cities to install a planned sewage system. Yet its liquid waste collection and disposal system is presently not in good state (Asmara Water Supply and Sewerage Project, 2007). Moreover, in the last 78 years, solid waste disposal in the city has been unorganized and lacks sustainable planning in its management (Asmait, 2016). Thus, as a result, a big dumping site developed east of the city along with other minor (iron, building material etc.) dumping sites at various locations in and around the city of Asmara.

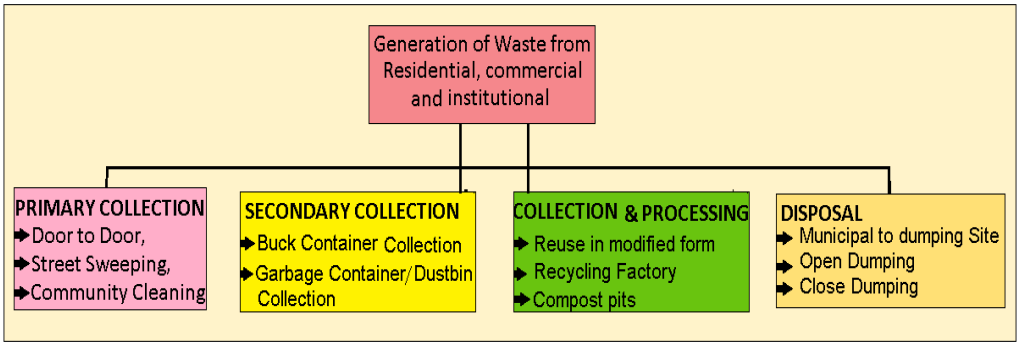

Figure 2: Channels of waste generation and their management in Asmara city
Source: Field survey, 2018.

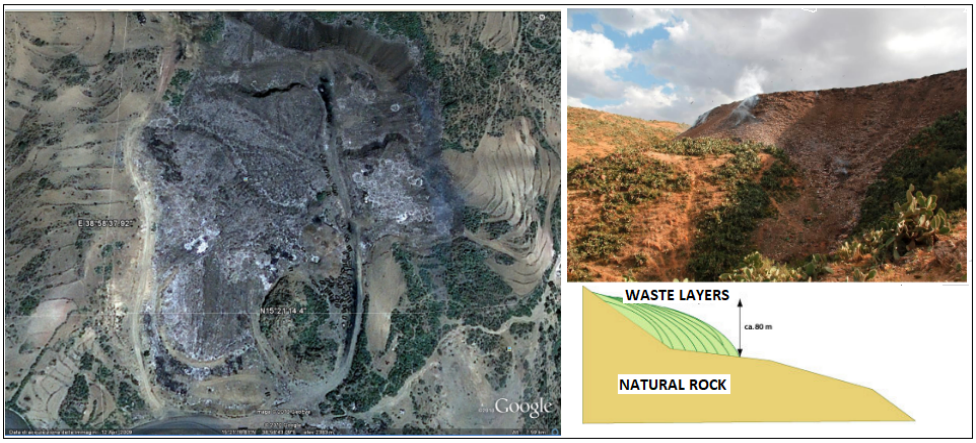

Figure 3: Asmara dumping site.
Source: EGEWR, 2011.

The main components of the solid wastes disposed off to the final disposal site of Asmara city located at Betghiorghish are organic components such as food wastes, paper, cardboard, plastics, textiles, rubber, leather, yard wastes, wood etc and inorganic components such as, glass, tin cans, aluminium, other metal, dirt, ash etc. Furthermore, it is noted that the residential waste makes up the greater percentage of the total solid wastes generated in the community of Asmara city (Table-1). The higher percentage of municipal waste with diverse nature is major challenges in its management as experiencing mostly in North- East Africa and other developing world (Shafy and Mansour, 2018).

Table 1: Solid waste composition by source.
Source: Sanitary unit of municipality Asmara, 2018.

Source	Sources include	Proportions (%)
Residential	All household and small shops waste	70
Industrial	All factories, slaughterhouses, garages, workshops and handicrafts	14.02
Commercial and markets	Market place wastes, entertainment centers, tea or coffee shops	4.4

Institutional	Government and governmental offices, international organization, College and schools	1.6
Hospital	Hospitals and health centers and pharmacies	1.6
Others	Street sweepings, plant trimmings, other constructions etc.	5.0
Total		**100**

3.2 Waste Generation in Asmara City

Spatial variation in the amount of solid waste generation depend upon growth and density of population, socio-economic structure of the people, level of urbanization, rise in the standard of living and stages of demographic transition (Shafy and Mansour, 2018). Asmara city have highly uneven distribution of waste generation and their collection. The amount of waste generation varies from one region to another local administrative area of the city. The northern local administrative area (LAA) such as Akria and Arbate-Asmara region generates highest amount of total waste (more than 200 q/d) while Maekel Ketema, Tiravolo and Adiguadad administrative region of central and southern part of the Asmara generates lowest solid waste collection (less than 100 q/d) in the city. Moreover, remaining administrative region of Asmara comes as medium range of waste generation (between 100 to 200 q/d) (Figure 5).

Moreover, per capita Asmara city generates less than 0.6 kilogram of solid waste i.e., equal proportion of per capita wastes as in the lower income countries (India, Bangladesh and Myanmar). While four administrative regions of the Asmara city generates more than 0.6 kilograms of solid wastes per capita is equal to waste generation from middle income group countries (Figure 6). The waste generation rates in Asmara city are equal to the low-income countries and much lower compared to middle income and developed countries (Matheson, 2019).

However, lifestyle changing very fast, especially in the high-income group of the people would use of more packaging material and per capita waste would increase. With the fast urban population growth in Eritrea at the rate of more than 4 per cent per annum -fourth highest among the African countries (Cowling, 2024), the yearly increase in the overall quantity, locality and per capita of solid waste in the city will be higher much higher in next ten years when total population of city will be doubled. The city has been constructed to habitat hundred thousand population by the Italians (Tewolde and Cabral, 2011). But after independence the populations the city has increased many folds. Presently the city inhabits more than half million population. There is positive relationship between population growth and waste generation according to the data generated. The population is expected to increase so the wastes generation also. It is estimated that by 2030 the population of the Asmara city will reach 1,034,517 and total amount of wastes will be generated to 44,059 tons.

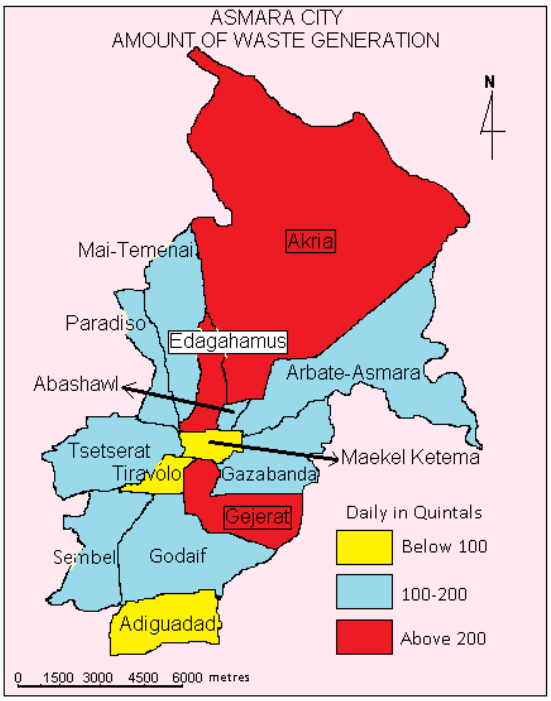

Figure 4: Amount of wastes generation.
Source: Maekel administration, 2018.

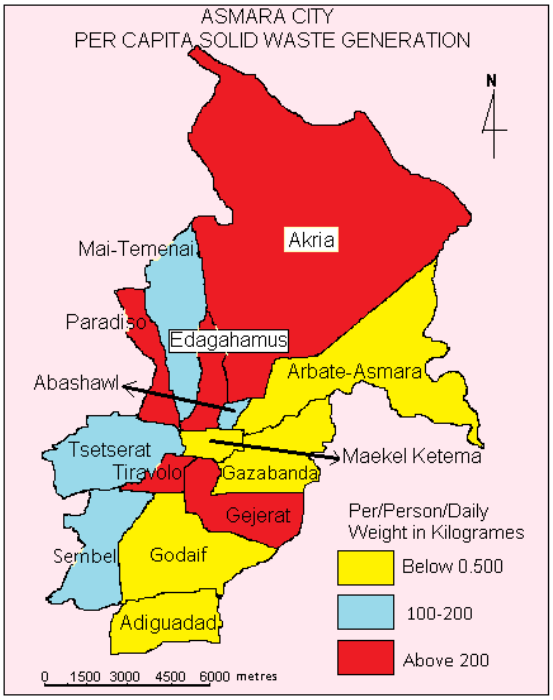

Figure 5: Per capita solid waste generation in Asmara city.
Source: Maekel administration, 2018.

Table 2: Total amount and per capita waste generated in Asmara city.
Source: Maekel administration, 2018.

	Sub zone	Waste generated		
		Total amount in Quintals	Household waste/day (kg)	Person/day (kg)
1	Tsetserat	105	2.5	0.575
2	Tiravolo	96	2	0.450
3	Berik	96	1	0.215
4	Mai-temenai	130	2.5	0.590
5	Peradiso	200	3.5	0.772
6	Godaif	190	2	0.422
7	Abashawl	200	2	0.500
8	Adiguadad	54	2	0.385
9	Maekel ketema	95	2	0.447
10	Sembel	100	2.5	0.520
11	Edagahamus	225	3	0.666
12	Akria	330	3	0.674
13	Gezabanda	181	2	0.444
14	Arbate –Asmara	240	3	0.671
15	Gejerat	173	2	0.449
Total		2415	2.3	0.67

Table 3: Trend of wastes dumped from Asmara city to the dumping sites.
Source: Maekel administration, 2018.

Year	Asmara population	Per capita (kg/day/cap)	Generated 1000 (t/year)
2007	489,825	0.43	7757
2008	506,099	0.45	8369
2009	522,905	0.47	9029
2010	540,260	0.49	9741
2011	558,182	0.52	10,508
2012	576,690	0.54	11,335
2013	595,802	0.56	12,227
2014	615536	0.59	13,189
2015	635,915	0.61	14,225
2016	656,957	0.64	15,343
2017	678,685	0.67	16,548

3.3 Solid waste generation and household socio-economic profile

There is direct relationship between solid waste composition and socio-economic activities of the community (Miezah at al. 2015). Municipal Waste Generation and their configuration are highly impacted by socio-economic profile of the people including size of the family and house size, income generation and the nature of employment. Socio-cultural, economic, legal, political and environmental factors as well as the available resources are the main issues that affect the Municipal Solid Waste MSW management in all countries (Kumar, 2011).

From the field survey it has been found that majority of the respondents in Godaif, Maitemenai and Sembel (Enda korea) are working in government sectors. While majority of residents of Abashawil and Maekel ketema are engaged in business activities. Size of the family also varies from one administrative area of the city to another. Except in the Enda Korea complex from the study sample all the administrative regions have large family size ranging between five to seven total numbers of family members. Total number of house size has strong relationships in the amount of wastes generations. However, among all the socio-economic variables, level of income has the positive relationships with the nature and types of households' wastes generation and their management and disposal (Deshpande et al., 2024).

Income is one of the significant variables for waste generation in the urban centers, therefore, from all the five sample administrative regions four categories of households' income levels have been identified as very low-income group, low income group, medium income group and high income group households. Based on the household income each sampled administrative region has been designated categories according to the majority of residents' income. Very low-income group categories are insignificant in the sampled areas; therefore it has been excluded from the categories. Thus only three categories of income groups have been outlines as low, medium and high income group in Asmara city. Low-income group region is Abashawl (50% low income people) and Godaif, Maitemenai and Sembel residential complex have been designated as medium income group region. While Maekel Ketema designated as high-income group region (Figure 8). Amount of waste generation recorded higher among the high-income group people comparison to low and medium income group people in the study region.

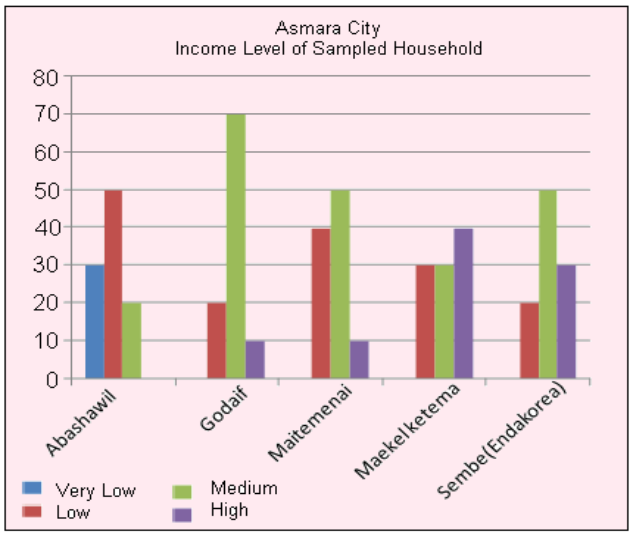

Figure 6: Income levels of sampled areas.
Source: Field survey, 2018.

Residential waste: Residential domestic waste forms the bulk of all resources of solid waste produced in the city. Further among the household, high-income groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Changes in waste composition can have a significant impact on waste management practices. Wastes may also contain hazardous such as pesticides,

paints, used medicine and batteries. Compostable organics include fruits, vegetables and food waste. Healthcare waste contains disposable syringes, sanitary materials and blood containing textiles and is governed by the Biomedical Waste (Management and Handling) Rules and should not be mixed with MSW (Acharya et. al., 2014). However, in the study region all the wastes including infectious medical waste mix with other waste before final disposal at dumping sites.

The composition of MSW produced by Asmara city dwellers is approximately 64.14 wt.% organic, approximately 11.7 wt.% of paper wastes, with approximately 8.64 wt.% is plastic materials, 2.62 wt.% is glass, 1.96 wt.% is metal and remaining other waste materials generated from the Asmara city dwellers. Their proportions vary among the high, medium and low-income group of the region. Low-income group localities have high proportion of organic matter in comparison of higher income group region where proportions of packages materials, plastic and steel materials are relatively in higher proportions (Table 4).

Table 4: Composition of solid waste in Asmara.
Source: Field survey, 2018.

Sampled Region	**Organic**	**Paper**	**Plastic**	**Glass**	**Metal**	**Others**
Abashawil	71.3	6.8	4.1	2.7	0	15.1
Godaif	59.7	14.9	11.9	2.2	3.2	8.1
Maitemenai	65.2	10.8	8.7	2.9	1.2	11.2
Makel Ketema	57	15	10	2.7	3.1	12.2
Sembel R.Complex	67.5	11	8.5	2.6	2.3	8.1
Average	**64.14**	**11.7**	**8.64**	**2.62**	**1.96**	**10.94**

Households' Storage: Solid waste can create problems inside the house if it is not properly stored in standard storage containers. Normally, containers should be strong, watertight, insect-resistant and tight fitting covers and should not exceed 60 pounds in weight when full. Table 5 shows that distribution of sampled household according to the nature of storage household waste inside the house. Majority of the households contains their waste in closed standard container (53.4 per cent) while 36 per cent residents keep their waste in open local container. However, open container storage varies from one region to another region in the study area. The waste contain in open container can attract flies in the house. So, they have more flies in their kitchen or in food preparations areas. Study found that low-income residential area has higher proportion of open household storage container in comparison to high income residential areas (Sembel residential complex) where higher proportions of closed standard garbage containers inside the house during the survey period. This may be due to the areas inhabited by high income people who are educated and know about the hazards of keeping wastes in open containers.

Table 5: Mode of household storage.
Source: Field survey, 2018.

Sampled Region	Open container	Closed standard container	Do not store	Total
Abashawil	56	20	24	100
Godaif	36	53	11	100
Maitemenai	56	35	09	100
Makel Ketema	25	70	05	100
Sembel R.Complex	03	95	02	100
Average	**36.4**	**53.4**	**10.2**	**100**

Households' disposal of waste: Safe disposal of household waste is very important in order to keep the locality environment surrounding cleans. The households deposed of waste through four different ways i.e. disposing to official collection points, house-to house collection by the municipality transport, dispose outside the house from where municipality vehicles collect it and dispose with the help of others by paying money according to the convenience, availability, and self-management.

Table 6: Modes of disposal of garbage from residential areas.
Source: Field survey, 2018.

Sampled Region	Waste disposal		
	Official Collection point	House-to house collection	Road side or Outside the house
Abashawl	00	00	76
Godaif	18	77	4
Maitemenai	17	68	15
Makel Ketema	27	58	15
Sembel R.Complex	97	00	03
Average	**35.5**	**42.6**	**21.8**

From the table 6 it seems that large numbers (almost 78%) of Asmara residents are disposes their household wastes officially either official collection points or through house to house collection by the municipality garbage collectors. Only low-income group locality Abashawl where there is no as such provision by the administration dumps large amount of waste outside the houses or they higher the people to dispose off their wastes to the other localities.

Waste/ garbage in the localities: Table 7 showing the amount of garbage found in the localities of sampled areas of Asmara. Amount of garbage found in the localities depends upon the waste management by the municipality and sanitary department of the Asmara city as well as by the management of community-based campaign. In general Asmara city is said to be clean city but, some areas are reported of wastes in some proportions due to poor involvement in sanitation program, irresponsibility and carelessness of some locality residents etc.

Table 7: Existence of garbage in Residential areas.
Source: Field survey, 2018.

Sampled Region	Existence of garbage				
	Spread everywhere	Not seen	Huge quantity	Small quantity	Negligible
Abashawl	**79**	21	12	85	03
Godaif	17	83	20	15	65
Maitemenai	21	79	18	17	65
Makel Ketema	27	73	07	12	81
Sembel R.Complex	05	95	02	08	90
Average	**29.8**	**70.02**	**11.8**	**51.4**	**36.6**

From the table 7 it has been found that very few areas complain the waste spread in their localities. Usually wastes are frequently removed by the concerned persons. Except Abashawl no part of the city where household wastes are spread on the streets according to the respondents' response. The Abashawl is the dirtiest areas of the city. The reasons could be lack of curb sides, trucks, bulk containers, lack of efficient administration in addition to the above-mentioned reasons. While most of the other localities are relatively clean.

Community Participation: Community based campaign for environmental sanitation is one of the major means to create awareness among the people about amount of wastes in their localities (Jena, 2018). Eritrea has strong social welfare campaign in almost all the sector of social life. Time to time Eritrean communities of localities themselves organize a cleaning complain in order to keep their localities clean. In the process of cleaning campaign, from every household a member is need to take participation in cleaning and landscaping of their localities. As per the finding of the field survey, most of the respondents said that they are engage in sanitation of their local area once per month, while the rest 11% said that this program is carried out once in three months.

3.4 Problems SWM and level of satisfaction

Solid Waste management has huge expenditure in developing nation cities. Management of waste generally accounts up to 50 percent of municipal operational budgets. (Zohoori and Ghani, 2017). Despite efforts high expenditures, cities just collect between 50-80 per cent of solid waste. Treatment or reuse of waste receives less attention in developing countries due to lack of fund. Therefore, up to 90% of waste collected in developing cities disposes off in open dumping sites without their treatment (Cointreau, 2008; Medina, 2010).

Table 8: Problems of waste management.
Source: Field survey, 2018.

Problems	Very serious (%)	Serious (%)	Not so serious (%)	No problem (%)
Inadequate service coverage	42	52	06	-
Lack of trucks and curbsides	24	64	12	-
Lack of equipment	24	52	24	-
Lack of legislation	08	40	50	02
Poor public co-operation	20	54	20	06
Poor co-operation of gov't agencies	12	48	36	04
Poor response to waste minimization(reuse/recycle)	92	06	02	-
Lack of planning	08	56	20	16
Lack of service quality	10	40	46	04
No proper institutional set up	02	30	68	-

Moreover, in areas where there is poor collection especially low and very low income localities of Asmara (Abbashawal and Maitemunai) inhabitants dump their rubbish on public space nearby or simply burn it in their backyards. Even open dumping of the waste illegally is the most popular disposal technique like other developing nation. Waste minimization (reuse /recycle) is one of the very serious problems facing the city since long time. Furthermore, lack of service coverage, lack of trucks/curb sides, lack of equipment, lack of public co-operation and lack of planning are some of the serious problems ever facing in the process of solid waste management.

The level of satisfaction regarding solid waste collection and their management was processed and presented in Figure 9. The wastes are handled, stored, collected and preparation of disposed of to the dumping site, which can pose risks to the micro-environment and to public health near-by disposal site. In urban areas, especially in the rapid urbanizing cities of the Eritrea, problems and issues of Municipal Solid Waste Management (MSWM) are of immediate importance. Both government management mechanisms and community base awareness have positive effects on wastes collection, transportation and disposal chains in the Asmara city. Abashawil, Godaif and Maitemenai where there is higher proportion of very low-, low- and medium-income group resides. In all three Local Administrative Regions (LAA), residents have poor approach towards waste storage and disposal. They keep their waste in open container in the houses and dispose illegally on the streets and other public spaces. Moreover, these areas improper waste disposal. All the above regions have high level of unsatisfactory response about the wastes management in their localities. Figure 9 shows that economic and social factors are among the major factors affecting the amount and management wasters in the localities of Asmara and their resultant level of satisfactions.

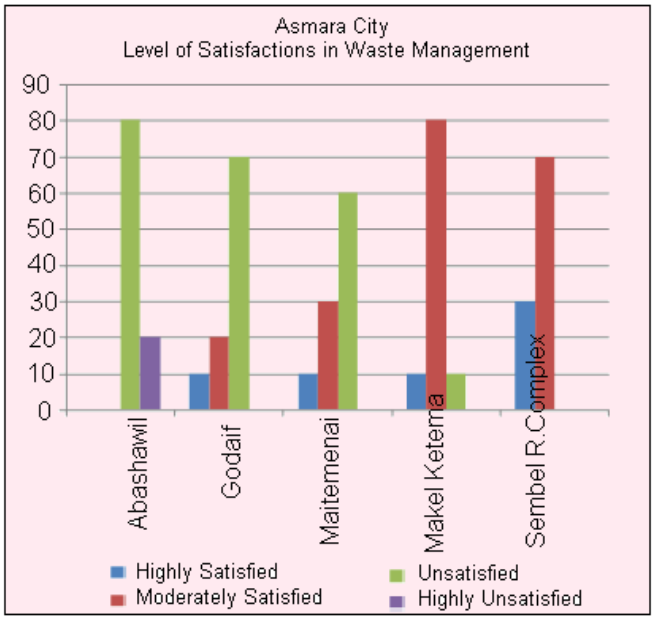

Figure 7: Level of satisfactions in waste management.
Source: Field survey, 2018.

4 Conclusion

Methods of waste collection to final disposal in Asmara city go through various levels before final disposal at only dumping site at Betghiorghish. Among the various sources of solid wastes, residential wastes contribute almost 2/3 of the total wastes in Asmara city. The waste generation rates in Asmara city are similar to the low-income countries and much lower compared to middle income and developed countries. In recent years, population growth has the positive relationship with solid waste generation in the Asmara city. Municipal Waste Generation and their configuration are highly impacted by socio-economic profile of the people. Low-income group localities have high proportion of organic matter in their waste in comparison of higher income group region where proportions of packages materials, plastic and steel materials are relatively in higher proportions waste.

From the field survey, it has been assessed that at household level almost 64 per cent are organic wastes. Together organic and paper wastes consist of total 75 per cent of household waste generated in the city. Almost 25 per cent of are recyclable wastes. However, wastes generated at household levels are not separated at primary levels rather all of them collected together at collection point and they dumped together at dumping site. It has also been found that income has direct relation with the management of waste, high income residential areas usually keep their waste in closed container as shows their awareness of health and household environmental sanitation.

Study found that the large numbers (almost 78%) of Asmara residents are disposes their household wastes at designated location managed by Asmara Municipality Corporation. There is also culture of community cleaning in each local administrative areas of the city. From the field survey, it has been found, management and services

of waste in each LAA in the city is not same. It is general trend, higher economic and government official residential areas are given priorities in services and amenities for collection of waste and their final disposal. While poorer and fringe areas of the city is being neglected in solid waste collection and their management. Thus, it also reflects in the level of satisfaction in the services pattern of waste management in the city of Asmara.

There is no private organization engaged in the city sanitation program. Asmara Municipality offices take the responsibility of solid waste management including the street sanitation. However, some localities in the city poor management in waste collection and disposal. Abashawil has no proper collection point and there is no systematic support from the municipality in waste collection and their disposal. Solid wastes collected from different waste generation sectors of the city such as residential, commercial, institutional, industrial etc. are dumped at Beitghiorghish with poor separation and recycle mechanism. Only small recycle unit of Eri-biodiesel recycling unit works for experimental level.

All kind of wastes dumped at dumping site are an open area without fence. Since it is situated along Asmara-Massawa road, it is becoming threat to the local inhabitants and tourists due to its smell and smokes of burned wastes. Apart from this, there is also a dumping site on the way to Asmara–Dekemhare road just beside the Asbeco construction company for the construction materials. It is an open dumping site exposed to wind and rainfall. Both the dumping sites do not have proper recycling waste management regulations. This is serious threat to the outskirts and local inhabitants' biodiversity of greater Asmara city region.

Recommendations

The rapid growth of population and changes in the lifestyle of the people from time to time have resulted in increasing amount in the nature and quantity of solid wastes generation in Asmara city. The wastes generated from different wastes generating sectors are not properly separated rather all together dumped at dumping sites. To overcome the difficulties and constraints it faces, the branch of solid waste management unit requires continuous attention, public awareness, provision of adequate equipment, manpower and investment from the department of social services and environmental sanitation branch. The future of environmental sanitation of the city as a whole will depend on how those issues are addressed by the combined efforts from the public, government, other stake holders, institutions and other sanitation units of the city. The following recommendations are important for improved solid waste management in the city:

- Society awareness should be increased through different social Medias and /or seminars about solid waste management.
- Since solid waste management operation is complex, it requires a skilled man power, therefore; adequate training should be given to the workers and municipality staff members to improve their skills.
- The number of street cleaners should increase to include areas which are full of wastes due to lack of street cleaners.
- Skin (hide) is one of the wastes polluting the city today especially during holy days. So, the concerned bodies should take care of these wastes.
- Introduce efficient segregation mechanism at household levels, collection centres and dumping sites so as to reduce the amount of waste, to composite the organic waste and re-use or recycle the other non-bio-degradable wastes.

- As the population size and amount of wastes are increasing, the city sanitary units should propose to get additional waste collecting trucks and bulk containers for effective and efficient waste collection.
- The government should allocate sufficient annual budget and concerned authorities have to work very hard on improving human, technical, financial and institutional capacities of the city sanitary unit for effective solid waste management.
- In general, there is an urgent need for the preparation of comprehensive (integrated) solid waste management plan in the city. All the concerned bodies especially the department of environmental sanitation need to develop national guidelines for safe disposal of municipal solid waste.

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Povzetek

Članek obravnava upravljanje s komunalnimi odpadki v Asmari, Eritreja, kjer urbanizacija, vse višji standard in spremembe življenjskega sloga povzročajo naraščanje količine odpadkov. Asmara se sooča z velikimi izzivi pri ravnanju z odpadki, zlasti zaradi neurejenega odprtega odlagališča v Betghiorghishu, ki ogroža biotsko raznovrstnost. Študija, izvedena z vprašalnikom, je pokazala, da obstaja pozitivna povezava med urbanizacijo in nastajanjem odpadkov. Prav tako so razlike v količini in vrsti odpadkov med različnimi gospodarskimi sloji, pri čemer višji dohodkovni sloji ustvarjajo več odpadkov. Za obvladovanje teh težav je nujno celostno trajnostno načrtovanje upravljanja s komunalnimi odpadki. V članku so obravnavane tudi metodologija raziskave, analiza problemov pri upravljanju z odpadki, skladnost z obstoječimi predpisi ter priporočila za izboljšanje sistema zbiranja in ravnanja z odpadki v Asmari.