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Quantification of Solid Waste in Bale Robe Town, Ethiopia

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ABSTRACT: In the present study the solid waste samples were collected from low, middle and high income groups for municipal solid waste quantification of Bale Robe Town. The data was collected randomly from 138 households, covering 3 kebeles (zone) at the rate of 46 households per kebele. Data was analyzed using SPSS Version 19. The household solid waste generation was 0.86 kg/household/day, 1.18 kg/household/day and 1.41 kg/household/day from low, middle and high income groups respectively; and on an average 1.15kg/household/day. The per capita residential solid waste generation was 0.15, 0.28 and 0.41 kg /capita/day in case of low, middle and high income groups and on an average 0.28 kg/cap/day. The per capita municipal solid waste generation i.e. including residential, commercial and street sweepings was 0.32kg/capita/day.

The composition of municipal solid waste consists of 12 types of components which were identified during segregation of waste. Food waste being the largest, contributes 50.18% by weight and 46.75% by volume. Ash has 19.19% by weight and 14.75% by volume and garden trimmings accounts for 10.83% by weight and 15.1% by volume. Present study revealed that residential solid waste generation showed non-significant positive correlation ($r = 0.996$, $p > 0.05$) with monthly income whereas non-significant negative correlation ($r = 0.995$, $p > 0.05$) was found with the average family size and household waste generation. To overcome the existing problems, municipal authorities should think about alternative options like composting, energy recovery options apart from educating the people about improper solid waste management practices.

KEYWORDS: Quantification, Municipal Solid Waste, Composition, Bale Robe

I. INTRODUCTION

Industrialization, urbanization and migration of people from rural to urban areas are reasons for the rapid expansion of cities beyond our expectations during the last few decades in most of the developing countries. The high increase in human population, its associated increase in urbanization and increase in economic activities has made the negative impact of solid waste management very noticeable in towns and cities around the world [2]. With the current growth rate of urban population in Ethiopia, it is estimated that the population of most urban areas especially small urban centers is doubling every 15-25 years. The booming growth of cities of the developing world has outpaced the financial and manpower resources of municipalities to deal with provision and management of services, of which solid waste is the major one [40]. Ethiopia is not an exception, it is facing rapid urbanization per annum, leading to overcrowding and the development of slums and informal settlements with poor waste management practices. Urban dwellers generally consume more resources than rural dwellers, and so generate large quantities of solid waste and sewage [21] In urban centers throughout African regions, less than half of the solid waste produced is collected, and 95% of that amount is either indiscriminately thrown away at various dumping sites on the periphery of urban centers, or at a number of so-called temporary sites, typically empty lots scattered throughout the city[20].

An integrated urban rural development study undertaken in 1988 showed that among the 11 project towns(Addis Ababa, Assela, Ambo, Arsi Negele, Nakamte, Goba, Mizan Tefferi, Robe, Wolisso, Ziway, Shashemene), only Addis Ababa had centralized waste disposal system[24]. Most municipalities in Ethiopia have become aware of the negative

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consequences of poor sanitation. 13 Out of 15 randomly selected large (Dessie, Bahir Dar, Bishoftu, Gondar, Mekele, Adama) and medium urban areas (Woldiya, Axum, Adigrat, Robe, Gimbi, Adwa, Arbaminch, Wolayita Sodo, Debremerkos) i.e. 86.6% used open dump to dispose waste, while the rest used holes. Most of the other urban areas in Ethiopia are believed to use open dump for disposal. Open dumps pollute surface and ground water, soil and the natural environment as a whole [40].

Management of solid waste is getting increased attention at national and local levels [31]. This is the main outcome of rapid growth of population and haphazard urbanization in developing countries[5]. Large volume of wastes generation and its disposal causes the degradation of environment in developing countries[4]. Improper municipal Solid Waste Management (SWM) will be a threat to public health and which leads to decline in the quality of the people's life[3]. Consequently, the uncollected waste which is often also accumulated with human and animal excreta is dumped indiscriminately in the streets and in drains, so contributing to flash flooding, breeding of insects and rodent vectors and the spread of germs or diseases[37]. Improper SWM greatly affects the urban poor, women and children who are vulnerable to health hazards. The U.S. Public Health Service identified 22 human diseases that are linked to improper municipal solid waste management. Without properly designing methodology and strengthening of the solid waste management system, it becomes very difficult to tackle this problem in future. After few years from now, solid waste generation rate will be many times more than what town is generating today. It takes great amount of effort, time and money to repair the damage caused on environment by the improper management of solid waste.

The Robe town has a total population of 80,503 with an estimated population density 7361inh/km²(Robe town Municipality 2014 report). It is one of the fast growing administrative and business centers endowed with hospitable climate. A number of tourists pass through this town from different corners of the world, to visit the nearby tourist attraction sites like the shrine of Dire Sheik-Hussein, the jungle of Harena-Buluk, Bale mountains national park and Sof Omar Cave, which is the longest cave in Ethiopia and runs for 15Km [16]. The unpleasant odor and unattractive appearance of piles of uncollected solid waste along streets and in fields and other natural areas can discourage tourism and the establishment and/or maintenance of businesses[12]. Since Robe town is situated close to Bale national park, the improper management of solid waste may affect eco-tourism also.

Benjamin & Mansoor(2004) have revealed that Municipal Solid Waste quantity and composition analysis is fundamental for the planning of municipal waste management services. The composition dictates the technology needed for waste processing prior to disposal [23]. But in Bale Robe town, no research had been undertaken on the solid waste quantification and composition. In the absence of such data, planning, designing and creation of facilities for SWM is practically not feasible. In the present study, composition and quantification of solid waste was taken up, which was very important and critical for providing of solid waste management services in Bale Robe town.

II. RELATED WORK

Solid Waste Management (SWM) is defined as the control, generation, storage, collection, transfer and transport, processing and disposal of solid waste consistent with best practices of public health, economic and financial, administrative, legal and environmental considerations[27]. Some authors also define municipal solid waste (MSW) as material which is useless or unwanted material discarded as a result of human or animal activity. Most commonly, it is solids, semisolids or liquids in containers thrown out of houses, commercial or industrial premises[13]. The major type and source of municipal solid waste are food, paper, plastic, glass, metals and various other households' items including street sweepings and general refuse from households, commercial, institutional establishments and non-hazardous solid wastes from industries[34].

According to UNEP (2004), solid waste generation has become an increasing environmental and public health problem everywhere in the world, particularly in developing countries. Developing countries have solid waste management problems that differ from those found in fully industrialized countries. Indeed, even the very composition of their waste differs from that of 'developed' nations. Notwithstanding, in low-income countries, solid waste generation rates

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average only 0.4 to 0.6 kg/person/day, as opposed to 0.7 to 1.8 kg/person/day in fully industrialized countries [42]. In several parts of Africa, thousands of tones of solid waste are generated daily. Most of this waste ends up in open dumps and wetlands, thereby contaminating surface and ground water and posing major health hazards. The waste generation rates, available only for selected cities and regions, are approximately 0.5 kilograms per person per day in some cases reaching as high as 0.8 kilograms per person per day[12].

For effective and economic management of solid wastes produced in a particular city, a considerable knowledge and data about the characteristics of the solid wastes of the respective city is a necessity. A waste manager, in order to decide or determine the types and quantities of facilities required for solid waste management and the best disposal options needed in a particular city, needs a precise information about the quantities (generation rate) and the nature of the constituents (composition) of the solid wastes produced in the city. Even to plan for future provision of facilities, projected increases in quantities of each waste stream (source) should be estimated[29].

According to Environmental Protection Authority (EPA) and World Bank study conducted in 2004, per capita amount of waste generated in Ethiopia ranged from 0.17 to 0.48 kg/person/day for urban areas to about 0.11 to 0.35 kg/capita/day for rural areas. The range depends on several factors such as income and season. As per world bank(2004) the total generation of municipal solid waste in Ethiopia in 2003 is estimated to be 2.8 to 8.8 million tones. This can be split to approximately 0.6 to 1.8 million tons from rural areas and 2.2 to 7 million tons from urban areas. The solid waste management in rural and urban areas differs starting from collection to disposal. In rural areas, the local authorities are not at all bothered about management of SW, the collection and disposal of SW is carried out by the local people only. Most of the biodegradable material is converted into manure and used as soil conditioner. In case of urban areas, it is the total responsibility of the concerned local authorities to deal with the problems of solid waste management (SWM).

As there is very limited effort to recycle, reuse or recover the waste that is being generated; waste disposal has been the major mode of waste management practice. When considering SWM in general, it should be noted that it is rather small fraction of waste that ever reaches dump sites or landfills in Ethiopia. Some studies have shown that only 43% of waste is collected in the country are properly collected and disposed in open landfills. The remaining waste is indiscriminately disposed in drainage lines, open spaces, street sides or is informally burned [41].

Like any other cities in the developing countries, day to day collection and disposal of solid waste(SW) in most of the cities in Ethiopia, is taken care by local authorities. The efficiency of SWM differs from one city/town to other city/town. In Bale Robe, People will store the SW in their premises and then transfer them into containers of the collection crew of the municipality. The collection and disposal practices is not upto the satisfactory level in Bale Robe. Due to this, scattering of plastic waste, plastic water bottles in the open drains and along the road side, street sweepings and general refuse from households with in the town limits is an indicator regarding the lack of facilities available with them. Creation of awareness among the public about adverse effects of improper SWM on environment and public health and equal amount of effort and encouragement from the government side in providing and promoting all the required facilities is the need of the hour.

III. METHODOLOGY

DESCRIPTION OF THE STUDY AREA

Robe is the capital town of Bale Zone. A suffix *Weleshe* is sometimes used to name as *Robe- Weleshe* so as to differentiate it from *Robe-Dida* of Arsi Zone. The town has been established in 1931 as a settlement area. Robe town is located in Oromia national regional state, in Bale Zone, Sinana Woreda. Astronomically, it is located at $7^{\circ} 3' 30''$ to $7^{\circ} 10' 45''$ North Latitude, and $34^{\circ} 57' 38''$ to $40^{\circ} 2' 38''$ East Longitude [15][22].

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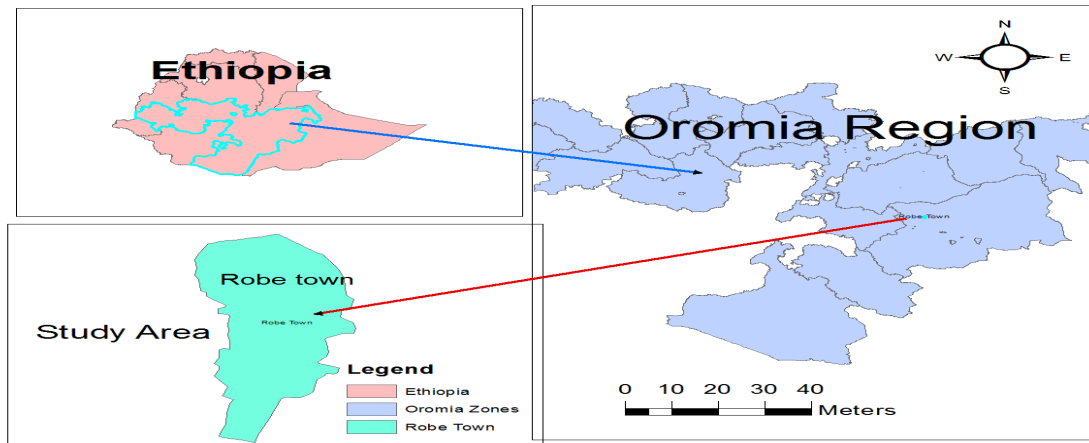


Fig. 1. The map of study area of Robe town (Source: GIS)

The average elevation of this town is 2,492 m above mean sea level and Bale Robe (fig.1) is located about 430 km from the capital city Addis Ababa. Robe is one of the reform towns in region and has a town administration, and three kebeles. Currently the town is categorized in 2B [15].

SAMPLING PROCEDURE

Simple random sampling method was employed to collect samples for quantification of Solid Waste (SW) in Bale Robe town from the selected households.

SAMPLE SIZE DETERMINATION

To determine sample size of households those who participate in the study, a sampling technique (formula), which was developed by Cochran to determine sample size (n) with the desired degree of precision for general population, was used. In this case population variable (P) was household's variable, and is given as [8].

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

Where

n= Sample size of households

P= Households variable (residential houses)

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

N= Total number of households

Z= Standardized normal variable and its value that corresponds to 95 % confidence interval equals 1.96

d = Allowable error (0.05)

Table 1: Population, Households and Housings units.

| Geographical area | Population | | | Number of households | Number of housing units |
|-------------------|------------|--------|--------|----------------------|-------------------------|
| | Both sexes | Male | Female | | |
| Robe-town | 80,503 | 40,845 | 39658 | 13,471 | 12,865 |

(Sources: Robe Town Municipality Report, 2014)

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AS per the statistical data collected from the public domain, there are 12,865 housing units and 13,471 households in Bale Robe(table 1).

$$\begin{aligned} \text{Sample size} = n &= \frac{NZ^2PQ}{d^2(N-1)+Z^2PQ} \\ &= \frac{13,471(1.96)^2(0.9)(0.1)}{(0.05)^2(13,471-1) + (1.96)^2(0.9)(0.1)} \\ &= 136 \end{aligned}$$

For the results to be reliable, the minimum no. of households, $n = 136$

In the present study, instead of 136, 138 households were considered. This was to have an equal distribution of sample size over 3 kebeles.

SELECTION OF PARTICIPATING HOUSEHOLDS

Before the selection of participating households, all households were divided into 3 categories; low, medium and high income groups. This classification was done based on: the discussion with owners/elders of the participating households & concerned local authorities, personally observing their living standards and house conditions.

The following family income /month were taken into account for the classification.

- a) <700 Birr (Low-income group)
- b) 701- 2,000 Birr (Medium -income group)
- c) >2,000 Birr (High-income group)

In a total of 138 households (HHs), considered for the solid waste collection in Bale Robe town, 46 HHs were allocated for each kebele. In each kebele, further sub-grouping of households was made based on the income status.

In each kebele, after randomly selecting the household numbers, survey was carried out to identify the participating HHs. If there were more number of HHs in any compound (housing unit), only one participating household was selected. For every participating HH, unique number was assigned. If any selected HH was not willing to participate, then other HH was selected.

DATA COLLECTION METHODS

After deciding the number of households from where the solid wastes were to be collected, the households were properly informed about the purpose of the study. One day before the collection of SW samples, two plastic bags were supplied with individually assigned identification numbers to each household for sorting organic fraction of the waste (i.e. biodegradable waste such as - food/kitchen waste, leaves, tree branches, wood waste, and agricultural) in one bag and non-biodegradable waste such as plastics, papers, textiles, metals, glass, rubber, leather and any waste in another bag. Further sorting was carried out by the sorters in the Madda Walabu University at pre-selected place. Supervisors, recorders & sorters were trained on all aspects of measurements, sorting and recording along with health-related issues concerning waste handling. The sorting team was instructed and made aware of the danger involved during the sorting of materials like: metal pieces, sharp objects such as nails, razor blades, hypodermic needles, and pieces of glass. Personal protective equipment was provided to all personnel involved in the study. Householders were informed about time (preferably early morning) of collection of samples from their home. Next day, collectors were transporting collected SW samples from householders to the sorting place. SW samples were collected for 4 Days (Two working days and two days during week end). Each horse cart was assigned a maximum of 46 samples. At the sorting place, 2 persons were involved in sorting and measurement of weight and volume of solid waste.

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SORTING BY WASTE TYPE



Plate 1. Sorting and weighing of municipal solid waste

The above plate (1) shows sorting and weighing of MSW. At the designated sorting place, SW collected from different groups was spread on the plastic sheet placed on a level ground surface for sorting purpose. The waste was sorted into different type of components. The sorted components include: food wastes, paper & cardboard & plastics, water bottles, textiles, rubber & leather, garden trimmings/yard waste, wood, glass, metals & tin cans, ashes/dirt/bricks, diaper, bones. The sorted wastes were weighed using scales of capacity 20 kg. The volumes of individual components were recorded using wooden box of known volume.

The percentage composition of each of the component was calculated by the formula:

$$\text{Percentage composition of waste fraction} = \frac{\text{weight of sorted waste}}{\text{Weight of total waste}} \times 100$$

III. RESULTS AND DISCUSSIONS

SOLID WASTE GENERATION RATE IN BALE ROBE TOWN.

The households of the town were divided into 3 groups: low, middle and high income groups. As the living standard of people increases, their purchasing capacity increases thereby producing more waste and vice versa in case of low income groups.

Table 2 : Household solid waste generation rate

| Descriptions | Low income | Middle income | High income |
|--------------------------------------|------------|---------------|-------------|
| Monthly income, per capita (in Birr) | < 700 | 701 – 2000 | >2000 |
| Number of households | 25 | 75 | 38 |
| Total weight, kg | 86 | 355 | 215 |
| Population | 146 | 317 | 131 |
| Avg. family size | 5.84 | 4.23 | 3.45 |
| Kg/HH/day | 0.86 | 1.18 | 1.41 |
| Kg/Capita/day | 0.15 | 0.28 | 0.41 |

There is an interesting relationship between buying capacity of the urban population and amount of the domestic waste generated [26]. Few earlier studies have suggested a close interrelationship between waste quantity/quality and socioeconomic status of households in developing countries[32]. An increase in income can change the consumption patterns of households which results in changed composition and quantities of HW [25].

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As shown in the table 2, households of different income groups such as low, middle and high income groups generate 0.86 kg/day, 1.18 kg/day and 1.41 kg/day respectively. Whereas the per capita solid waste generation rate was 0.15 kg/capita /day, 0.28 kg/ capita /day and 0.41 kg/ capita /day for low, middle and high income groups respectively. The waste generation rate was higher in case of higher income group residents when compare to lower income group residents.

COMPOSITION OF SOLID WASTE

In urban areas, the heterogeneous nature of waste makes the management of solid waste difficult and complex. Table 3 shows the composition of solid waste from the residential areas of the selected households. In the study area, the % of biodegradable component (shown in table 3) was more than 60 % of the total waste. From the selected households (138), food waste constitutes 50.18% of the total waste by weight and 46.75% by volume. Earlier studies also showed that large portion of solid wastes of developing countries is food wastes [35].

The second place was occupied by garden trimmings, amounting to 10.83% by weight and 15.1% by volume respectively. Due to high rainfall (avg. annual rainfall: 941 mm) and cold conditions (avg. annual temperature 22.3°C) [17] greenery was there in all the compounds throughout the year. Garden trimmings or yard waste includes- garden waste, use of grass in the restaurants and coffee shops, sticks and leaves of chat etc. Bale Robe receives truck load of chat every day. As per Ambaye G, (2012) the number of chat chewers increased significantly over the years in Ethiopia. Previously, chat was mainly cultivated and chewed in the eastern part of the country. Now a days, evidence shows that chat was spreading to all Ethiopian geographic regions, religious and ethnic groups, due to this substantial amount of sticks and leaves of chat was present in the yard waste.

The third largest % of waste component was ashes/dirt/bricks etc. at 19.19 % by weight and 14.75% by volume. The survey conducted in the study area indicates that 73.91% households use traditional kitchens where residents use charcoal, firewood and cow dung as their source of energy for cooking. Because of this, the ash content was consistent and present in large amount in waste composition.

Table 3: Residential solid waste composition

| Sl. No. | Components | Weight | Volume | % by weight | % by volume |
|---------|-----------------------------|--------|--------|-------------|-------------|
| 1 | Food wastes | 43.01 | 115.83 | 50.18 | 46.75 |
| 2 | Paper, Cardboard | 2.1 | 10.26 | 2.5 | 4.73 |
| 3 | Plastics, water bottles | 3.42 | 22.26 | 3.98 | 8.6 |
| 4 | Textiles | 2.04 | 11.25 | 2.38 | 4.08 |
| 5 | Rubber, leather | 2.1 | 4.73 | 2.45 | 1.6 |
| 6 | Garden trimmings/yard waste | 9.29 | 35.57 | 10.83 | 15.1 |
| 7 | Wood | 0.66 | 0.85 | 0.77 | 0.34 |
| 8 | Glass | 2.89 | 6.2 | 3.36 | 1.77 |
| 9 | Metals, tin cans | 1.1 | 1.51 | 1.28 | 0.45 |
| 10 | Ashes/Dirt/Bricks etc. | 16.45 | 32.48 | 19.19 | 14.75 |
| 11 | Diaper | 2.54 | 5.79 | 2.96 | 1.76 |
| 12 | Bones | 0.11 | 0.08 | 0.13 | 0.075 |
| | Total | 85.71 | 246.81 | 100 | 100 |

Along all most all roads in Bale Robe, one can see indiscriminate disposal of plastic covers (festal) and all drains have become dumping places of wastes especially plastic covers and empty water bottles. Scattering of plastic waste can be found near solid waste dumping site and in the outskirts of the town (plate 2) along the road sides.

Plastic wastes constitute 3.98% by weight and 8.6% by volume of the total waste generated. The other was, Glass waste consists of broken glass cups, medicine bottles, alcoholic beverage bottles and broken pieces of glass used in construction. It contributes only 3.36% by weight and 1.77% by volume.

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Plate 2: Indiscriminate disposal of SW in an open drain & scattering of plastic waste in an open area.

Diapers were present in the domestic wastes of middle and high income groups; it's contribution was 2.96 % by weight and 1.76 % by volume. Nowadays, parents started using disposable diapers for children's feces, a common practice in many economically stable families. Improvement of economic conditions in future increases the % of diaper in waste composition. The rubber and leather waste % by weight and volume was 2.45 and 1.6 respectively. The worn-out slippers, shoes, belt etc contribute to this waste. The paper & cardboard waste amounts to 2.5% by weight and 4.73% by volume. The contribution of textile in the form of pieces of torn cloth/rags in the waste stream was 2.38% by weight and 4.08% by volume. The least % of wastes in terms of % of weight and % volume were metal waste, wood and bone pieces. They were present in the order 1.28%, 0.77% & 0.13% by weight and 0.45%, 0.34% & 0.075% by volume respectively. The waste components which have resale value in the market such as metal waste, jerry cans, bottles etc, minimize the quantity of SW to some extent and appear less in the waste stream.

TOTAL WASTE GENERATION RATE

For efficient and effective SWM in any urban area, apart from finance and manpower, information regarding quantity and quality of SW is very much required. To determine the number of collection vehicles and number of trips from town to the disposal site, the quantity of solid waste data is essential. The per capita generation was determined using the following formula:

Per capita residential waste generation =

$$\frac{\text{Weight of MSW generated at HH}}{\text{Total number of persons in the HH} \times \text{Total number of waste generation days}}$$

Total number of persons in the HH x Total number of waste generation days

$$= 656 / (594 \times 4)$$

$$= 0.28 \text{ kg/capita/day}$$

The per capita residential solid waste generation rate was 0.28 kg/capita/day.

Table 4: Population projection of Bale Robe town.

| Population | Male | Female | 2013 | 2014 | 2015 | 2016 |
|------------|--------|--------|--------|-------|-------|-------|
| Total | 40,845 | 39658 | 80,503 | 84045 | 87743 | 91604 |

(Sources; Robe Town Municipality report, 2014 E.C)

As per the records of town municipality, the total population of Bale Robe in the year 2013 was 80,503. Considering the population growth at the rate of 4.4%, 2016 population of the town was calculated and reported in table 4.

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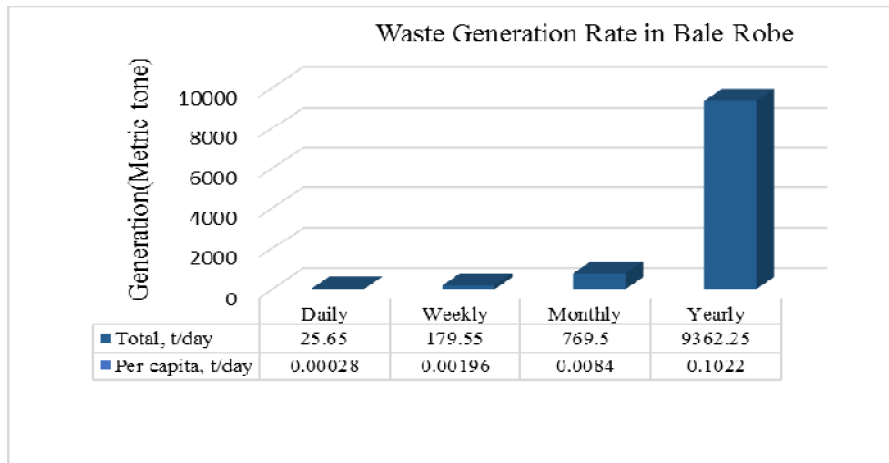


Figure 3: Daily, weekly, monthly and yearly waste generation rate

Considering the population of 2016, the daily, weekly, monthly and yearly solid waste generation rate was estimated and shown in figure 3.

STREET SWEEPING IN BALE ROBE TOWN



Plate 3: Researcher discussing & collecting information with street sweepers.

Street sweeping activity was included in the MSWM (plate 3). The town has 7Km of road from Madda Walabu University to Technic. Three street sweeping groups in the town consisting of 35 members, take care of this activity. Except Sunday, they sweep the roads remaining days (Monday to Saturday). Regular cleaning was required to remove solid wastes like animal waste, paper and plastic waste, remains of chat and fruits, dust entering the asphalt roads from adjacent mud roads. The sweepers use brooms for street cleaning and they work in the early morning hours. The street sweepings excluding dust (i.e. Mud) was temporarily stored in small heaps along road sides and transported to disposal site using three donkey carts(*gari*) twice a week i.e. on Monday and Wednesday. It was observed during the study period; sweepers will throw the dust to the footpath area (plate 3). The samples were collected from five different places, considering stretch of 10 meter per sample. The weights recorded from sampling point 1 to sampling point 5 were: 0.7 kg, 0.4kg, 0.9kg, 1.1kg and 0.6 kg. For one kilometer road stretch, the total amount of waste generation was 0.074 t.

$$\text{Total weight of street sweeping} = 7 \text{ km} \times 0.074 \text{ t} = 0.518 \text{ t / day}$$

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COMMERCIAL WASTE

Commercial and institution wastes were produced from business areas such as offices, shops, restaurants, hotels, banks, educational institutions etc, composition of residential and commercial wastes were almost similar but percentage varies. For the determination of quantity of SW, the sample size was fixed as 15 from 3 kebele at the rate of 5 samples from each kebele.



Plate 4: Storage of commercial waste before disposal

The above plate (4) shows the storage of commercial waste adjacent to their business place. There were 3950 commercial houses which include shops, hotels and restaurants. In addition to this, 1005 residential cum commercial establishments were present (Robe Town Municipality, 2014). Commercial houses produce solid waste at the rate 0.15kg and residential cum commercial establishments (excluding residence) produce 0.1kg of solid waste per day.

Therefore; currently total daily waste generation in Robe town:-

Quantity of solid waste from commercial areas = $(3950 \times 0.15) + (1005 \times 0.1) = 693 \text{ kg/day}$

Quantity of solid waste from residential areas = 25,650 kg/day

Quantity of solid waste from street sweepings = 518 kg/day

Add 10 % for unaccounted = $0.1 \times 26,861 = 26,86.1 \text{ kg/day}$

Total amount of solid waste = 29,547.1 kg/day

Per capita municipal solid waste generation = $(29,547.1 \text{ kg/d}) / (91604) = 0.32 \text{ kg/capita/day}$.

Table 6: Income level of participating families in the study area

| Monthly income (Birr) | Frequency | Percentage | Valid percentage | Cumulative percentage |
|----------------------------|-----------|------------|------------------|-----------------------|
| < 700 (Low income) | 25 | 18.12 | 18.12 | 18.12 |
| 701 - 2000 (Middle income) | 75 | 54.35 | 54.35 | 72.47 |
| > 2000 (High income) | 38 | 27.53 | 27.53 | 100 |
| Total | 138 | 100 | 100 | |

Table 6 shows the income level of participating families in the study area. 54.35% of the families belongs to middle income group, 27.53% of the families belongs to high income group and 18.12% belongs to low income group. According to the results obtained from 1999/2000 Household Income, Consumption and Expenditure (HICE) and Welfare Monitoring (WM) Surveys of the Central Statistical Agency[9], about 44 percent of the total population (45% in rural and 37% in urban areas) were found to be below poverty line, while the results of the 2004/05 surveys revealed that about 39 percent of the total population (39.3% in rural and 35.1% in urban areas) were found to be under the poverty line. According to the report on poverty analysis study made by the Ministry of Finance and Economic Development 2010, using Household Consumption and Expenditure Survey, shows that the poverty rate has declined to 29.6 percent.

Year on year the percentage of poverty is decreasing and moving towards higher income levels, an indication of economic growth in the region. A high rate of population growth and increasing per capita income have resulted in the

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generation of an enormous volume of solid waste, which poses a serious threat to environmental quality and human health [30].

FAMILY SIZE

All over the world, it was observed that as economic status of the family increases solid waste generation rate also increases. The high income group and low income group showed great variations in terms of total waste generation and quality of the waste. There was great variation in the quantity of waste generation in different family size in the urban areas. As family size and income are the most significant factors affecting the quantity of solid waste from household consumption, a study on the relationship among these is vital in the decision making on waste management strategies [28].

Table 7: Family size of participating households

| Number of persons | Households | Percentage |
|-------------------|------------|------------|
| 1 | 2 | 1.5 |
| 2 | 24 | 17.4 |
| 3 | 28 | 20.29 |
| 4 | 32 | 23.19 |
| 5 | 18 | 13.04 |
| 6 | 15 | 10.82 |
| 7 | 8 | 5.8 |
| 8 | 6 | 4.35 |
| 9 | 3 | 2.17 |
| 10 | 1 | 0.72 |
| 11 | 1 | 0.72 |
| Total | 138 | 100 |

Table 7 shows family sizes of the participating households. Families, with four members accounted for 23.19 % (32), and family size of three accounted for 20.29 % (28) ranking second. Households of family members ten and eleven accounted for 0.72% being the least in the family size.

The per capita waste generation rate decreased with an increase in family size and the household waste generation rate went up with larger families. As found in the pilot study (Dangi et al., 2008), waste generation leveled off in decreasing order from wealthier strata to less well-off strata (from higher to lower middle-income), but the trend did not hold for the least well-off strata (low-income).

Table 8: Average family size of participating households

| Monthly income (Birr) | Frequency | Percentage | Average family size |
|------------------------------|-----------|------------|---------------------|
| < 700 (Low - income) | 25 | 18.12 | 5.84 |
| 701 – 2000 (Middle – income) | 75 | 54.35 | 4.23 |
| > 2000 (High - income) | 38 | 27.53 | 3.45 |

The above table (8) shows average family size of participating households based on income group. The overall average family size of participating households was about 4.30(Av. Family size = household population / total households = 594/138=4.30), which was slightly lower than that of overall family size of urban population of Ethiopia 4.7 [9].

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Correlation between household waste generation and total monthly income

Table 9: Correlation between income level and household solid waste generation

| | | Kg/HH/day | Monthly Income (in Birr) |
|--------------------------|---------------------|-----------|--------------------------|
| Kg/HH/day | Pearson Correlation | 1 | .996 |
| | Sig. (2-tailed) | | .060 |
| | N | 3 | 3 |
| Monthly Income (in Birr) | Pearson Correlation | .996 | 1 |
| | Sig. (2-tailed) | .060 | |
| | N | 3 | 3 |

$r=0.996$ $p=0.060$

The correlation study has revealed that household solid waste generation rate was positively correlated with monthly income of the family ($r = 0.996$, $p>0.05$) i.e. the solid waste generation increases with increase in family income, although not significant at 5% probability. Visvanathan & Trankler (2003) reported that in a family with rich socioeconomic condition, daily waste generation rates were generally higher than the lower socioeconomic families.

Correlation between average family size and household waste generation

Table 10: Correlation between average family size and household solid waste generation

| | | Avg. Family Size | Kg/HH/day |
|------------------|---------------------|------------------|-----------|
| Avg. Family Size | Pearson Correlation | 1 | -.995 |
| | Sig. (2-tailed) | | .066 |
| | N | 3 | 3 |
| Kg/HH/day | Pearson Correlation | -.995 | 1 |
| | Sig. (2-tailed) | .066 | |
| | N | 3 | 3 |

$r = -0.995$ $p=0.066$

In the present study, a non-significant negative correlation ($r = -0.995$, $p>0.05$) was found between average family size and household waste generation, i.e. with the increase of average family size household solid waste generation reduces. Irwan. D (2011) also revealed that the average daily per capita MSW discharge rate depends on number of persons that makes up a household. Bigger households with more than 5 members have a lower average daily waste discharge rate per capita when compared to households that have a lesser number of residents.

IV. CONCLUSION AND RECOMMENDATIONS

CONCLUSIONS

The study was conducted to assess the composition of solid waste along with determination of amount of HH solid waste generation rate and per capita waste generation rate. The study revealed the following points:

- The average family size of Bale Robe was about 4.30, which was lower than that of overall family size of urban population of Ethiopia 4.7(CSA, 2007).
- The household solid waste generation was 0.86 kg/cap/day, 1.18 kg / HH / day and 1.41 kg/HH/day from low, middle and high income groups respectively and on an average 1.15kg/HH/day.

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- The per capita residential waste generation was 0.15 kg /cap/day, 0.28 kg /cap/day and 0.41 kg /cap/day in case of low, middle and income groups and on an average was 0.28kg/cap/day.
- The per capita municipal solid waste generation was 0.32 kg /cap/day.
- The composition consists of 12 types of components identified during segregation of waste. Food waste being the largest contributes 50.18% by weight and 46.75% by volume.
- Ash comprises 19.19% by weight and 14.75% by volume and garden trimmings accounts for 10.83% by weight and 15.1% by volume.
- More than 60% of the waste was decomposable organic material.
- The correlation study has revealed that household solid waste generation rate was positively correlated with monthly income of the family($r = 0.996$, $p > 0.05$) i.e. the solid waste generation increases with the increase in family income, although not significant at 5% probability.
- Non- significant negative correlation ($r = - 0.995$, $p > 0.05$) was found between average family size and household waste generation, i.e. with the increase of family size the household solid waste generation reduces.

RECOMMENDATIONS

In any urban setup, financial support from the municipality plays an important role in managing SWM issues efficiently. Most of the urban areas in Ethiopia are struggling to overcome the problems concerning SWM due to rapid increase in population over the past decades and inability of municipalities to expand its infrastructure and Manpower capability.

- Indiscriminate disposal of SW in the town is causing health problems, environmental pollution and spoiling aesthetic beauty of the town. Since the residential waste contribution is very high compared to commercial sectors, SWM service charges for residential areas should be fixed on monthly basis rather than quantity. If the charges are on monthly flat basis, Public will hand over the total quantity of waste generated to the collection crew thereby preventing illegal dumping and burning of SW.
- With the support and co-operation of the public, solid waste management can be implemented effectively. When public learn about the adverse effects of improper SWM, their co-operation level rises. The responsibility of creation of awareness among the public lies with the concerned authorities. Government organizations, NGO's, educational institutions can play a role in educating the public and also the younger generation at school levels about the better quality of life with efficient SWM.
- More realistic data requires long term study which includes all the seasons. Quantification of MSW within a period, extending up to one season may produce unrealistic results. The reliability of the result depends on many factors such as SW sample collection frequency, collection of samples during different seasons, public attitude, legislation etc.,. However, the data given in this research can be used to plan MSWM on a broad basis; which has further scope towards improvisation and technological intervention.
- Public should be encouraged to practice 3 R's (reduce, reuse and recycle), to reduce the quantity of plastic, paper and metal waste reaching the disposal site.
- More than 60% of the residential waste is organic. Instead of dumping this waste at the disposal site, alternate technologies like composting, biogas generation should be practiced. This will be a win-win which not only reduces load on Municipalities but also leads to energy recovery and enhancement of soil fertility.
- Solid waste collection bins are totally absent in Bale Robe town. Littering of waste material all over the town can be minimized, by providing sufficient number of dust bins within the Municipal limits.
- Municipality is depending on donkey cart (Gari Harre) for transportation of SW from town to disposal site. It is humanly impossible to cover the entire town by using 3 carts. Municipality has not provided daily collection of SW to all the households in the town. It's always better to switch over to modern SW collection and transportation vehicles, so that efficient services can be extended to the public.

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