International Journal of Science, Environment and Technology, Vol. 5, No 1, 2016, 47 – 58

ISSN 2278-3687 (O)
2277-663X (P)

MUNICIPAL SOLID WASTE COMPOSITION CHARACTERIZATION FOR SUSTAINABLE MANAGEMENT SYSTEMS IN MBEYA CITY, TANZANIA

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Abstract: Solid waste management (MSWM) is one of the most challenging issues faced by developing countries including Tanzania: Most urban areas suffer from serious environmental pollution problems caused by the generation of large waste quantities of solid waste including Mbeya city. Thus, this paper examines municipal solid waste composition characterization (SWCC) in supporting the sustainable management systems (SMS). The paper uses results obtained from a survey of 221 households from the 9 randomly selected wards out of 36 wards of Mbeya city. Waste characterization method adopted was site-specific sampling via sorting and weighing refuse by category. Sorting and determination of composition was carried out in primary and secondary collection points in the study area. The results obtained shows there is no variation between the composition of solid waste in primary and secondary collection points. Such trend implies that the system of solid waste management have no effect on the percentage composition of waste. Moreover, there is no effort done by people at the household level in treatment of the waste. Thus the status of waste at the primary collection points almost remains the same as at the secondary collection points. The study realized a great potential the solid waste bear in terms of recycling and compositing at house hold and community levels.

Keywords: Solid waste composition, household collection points, community secondary collection points, recycling, compositing, Mbeya city.

1.0 Introduction

Solid waste generation (SWG) has become an issue of concern every where in the world, particularly in urban centers. SWG is one of the most challenging issues faced by developing countries that suffer from serious environmental pollution problems caused by the generation of large waste quantities of solid waste (Al-Khatib *et al.,* 2010). Increased generation of waste in cities has aggravated sanitary related problems due to inadequate provision of basic services like water supply, sanitation facilities, transport infrastructure and waste management (UNCHS, 2001; Lyeme, 2011).

*Received Dec 22, 2015 * Published Feb 2, 2016 * www.ijset.net*

Studies reveal that storage, collection, transportation and final disposal of wastes are reported to have become a major problem in urban areas (ADB 2002; Kaseva & Mbuligwe 2005; Okot-Okumu & Nyenje 2011; Rotich *et al.,* 2006) where as cities in East Africa are also victims of the same problem. This problem is attributed by poor economic base which accounts to low achievement in all processes encompassed in solid waste management. Most developing countries fail to address the issue of solid waste because of the competing priorities over the limited resources available. This makes solid waste generation to be one of the serious problems many cities are faced with. Effective MSWM is a function of so many factors put together which include political, legal, socio-cultural, environmental, economic factors and available resources (Al-Khatib *et al.,* 2010). This means that adoption of any new technology for sustainable management of solid waste must take into account the influence of such factors in the community.

SWG rates and composition vary from country to country depending on the economic situation, industrial structure, waste management regulations and life style (Pipatti, *et al.,* 2006). For effective planning and development of strategies for sustainable management of solid waste, information about the quantity and categories of waste is of great importance. Thus in the modern world, quantification and characterization are the most important processes of all sustainable solid waste management systems (Senzige, *et al.,* 2014). Studying the composition of solid waste categories at a particular place, realizes the environmental potential the waste bears on integrating technologies like recycling and resource recovery in the solid waste management systems. The information also assists in planning, policy development, and infrastructure sizing decisions for various phases of an integrated solid waste management program (Alqader and Hamad, 2012). Information about the amount of different type of solid waste generated is a key step in deciding on the suitable waste management option to go for. The same contention is held by (Acurio, *et al*., 1997) who argues that any decision made for adequate solid waste management should be based on better understanding of composition. Solid waste generation and composition influenced by several factors among which include the socioeconomic factors such as monthly income, average family size, number of room(s) and employment status (Sankoh *et al*., 2012). In other studies it has been have found that there is a direct correlation between social activities and the solid waste composition (Gidarakos *et, al*., 2005). Among other factors consumption of goods and change in the source-sorting behavior affect also the quantity and composition of the solid waste in households (Dahlén, 2008). It has been found by other scholar that the amount and composition of per capita household waste generation may be influenced by socio-economic, seasonal, regional and waste management /institutional factors (Parfitt, *et al.,* 1994).

This paper aimed at assessing the composition of solid waste in primary and secondary collection points in Mbeya city. The information obtained could be useful in planning for the suitable technique for reducing the quantity of waste which is required to be transported to the landfill. Application of any MSWM technique that diverts solid waste away from the landfill could reduce a considerable amount of money that is to be spent in transporting the waste from their secondary collection points to the final disposal site (Mlozi, 2011). Therefore the paper makes comparison of the solid waste composition between the solid waste stored in house hold and those already sent to the community secondary collection points.

1.1 Description of the Study Area

Mbeya City is situated in the south western part of Tanzania along the Tanzania Zambia (TANZAM) highway and the Tanzania Zambia Railway line (TAZARA). It is located within Mbeya District, lying between latitudes 8°50' and 8°57' South of the equator and between longitudes 33°30' and 35°35' East of the Greenwich meridian and borders. Mbeya City is the headquarters of Mbeya region and is conveniently accessible by road and railway from Dar es Salaam (830km North East). Administratively, Mbeya City is divided into two divisions namely lyunga and Sisimba which are further subdivided into 36 Wards as shown on the map (Figure 1) and 181 hamlets.

Major economic activities in the city include commerce and trade, agriculture and livestock keeping, industrial production and service provision. It is estimated that 33.3% of City residents depend on agriculture for their livelihood. 21% are employed in the public sector mainly dealing with service provision and 43.4% are engaged in the informal sector where they work with small scale production, petty trade and selling of agricultural crops and 2.3% contribute as family workers and other businesses.

Mbeya City Council is situated at an elevated land along the slopes of Mount Mbeya ranges at an altitude rising from 1600 to 2400 meters above sea level. The city is characterized by moderate climate, with the mean annual rainfall of 1200 mm received between November – May which is accompanied with mean temperature ranging between 11^0C – 25^0C.

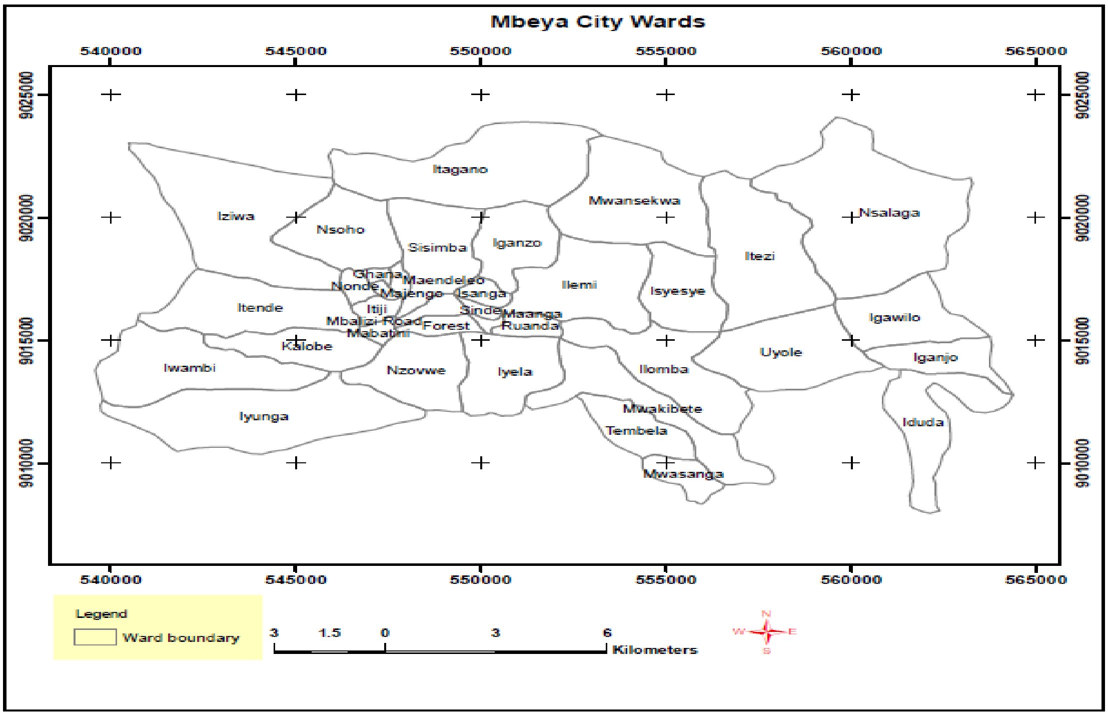

Figure 1: Map of Mbeya City Council Ward Boundary

1.2 Municipal Solid Waste Generation in Mbeya City

According to MCC (2008/9) annual report shows that the solid waste generated daily was about 167 tons and the generation rate per person per day is 0.5kg (Gidde *et al*., 2008) where as the population size was about 337,109 people. Out of the total amount generated only 74 tons equivalent to 44.3% was collected and disposed per day (Mlozi, 2011). Such low achievement was attributed by inadequacy of facilities, as there were only 2 skip-masters, where as, only one was operational. In additional to that, there were four (4) side-loaders and two (2) tippers (MCC, 2009).

The solid wastes in the city have different sources of origin. Some are generated from business centers while others originate from household. The waste from the business centers includes the all discarded materials from the production line. The household waste results from materials of consumer and non-consumer origin redundant by individuals in the household. This is a common understanding as the actual flow of waste within the household has not yet been adequately studied.

1.3 Solid Waste Management System in Mbeya City

The collection and transportation of solid waste in mbeya city is entirely carried by the City council. The wastes are first owned by the generators before taking either to the dumpsite or to the secondary collection points. The large solid waste generators like production industries have their own secondary collection from which the City council's truck loads and transport them to the final disposal site. In households members keep the solid waste in small bins or bags and there after carries them to the designated secondary collection points. Such collection points are in form of either an enclosure or just an open place. In some other points there are containers (skip buckets) which can accommodate at least four tons of solid waste.

2.0 Methods and Materials

Among other methods used in the waste characterization are the materials flow method and site-specific sampling via sorting and weighing refuse by category (Alqader and Hamad, 2012). The material flow methods are applied in industries where data for input and output from the processes are monitored to classify and quantify the waste generated. Site-specific sampling via sorting and weighing refuse by category was adopted in this study. However, in this paper the samples collected were depended on the availability and heterogeneity of the solid waste at the household and designated secondary collection points (Senzige, *et al.,* 2014).

All the wards have one characteristic in common they are characterized by patches of areas with planned settlements and squatters. This makes demarcation of ward based on the household economic status become even more complex. For the sake achieving the objective of this paper, the author stratified the area of study basing on the population size of the ward and their geographical location as indicated in Table 1. From the sampled wards, a total of 221 households were randomly identified. Families from the identified households were asked to keep the solid waste in bins for five days. There after sorting and weighing of materials categories was carried at each household.

The sorting and weighing of solid waste was also done at the designated community secondary collection points. Since there is no specific method used for specifying the number of samples for solid waste characterization (Al-Khatib *et al.,* 2010; Senzige, *et al.,* 2014), in this paper six collection points in each ward were identified and used.

Table 1: The Wards and Households Sampled

Ward	Population size in each ward	Number of Households in each ward	Household sample size in each ward
Ilomba	34,021	8100	41
Iyela	31,634	7532	38
Ilemi	26,841	6391	32
Nzovwe	22,898	5452	27
Nsalaga	18,993	4522	23
Itezi	18,445	4392	22
Iyunga	15,026	3578	18
Iwambi	12,387	2949	15
Sisimba	4,112	979	5
Total	**184,357**	**43895**	**221**

2.1 Sorting and Weighing of Material Categories

2.1.1 From households

The sample of solid wastes collected from households weighed between 20 – 60kg. At each household the wastes were sorted into various material categories as defined in Table 2. The materials were classified into nine categories namely; plastics, metals, papers, textiles, organics, inert waste, glasses, and woods. This system of classification of materials based on previous studies (Gidarakos *et, al.*, 2005; Alqader and Hamad, 2012; Senzige, *et al.,* 2014). Each sorted material category was weighed independently and the data recorded in the data sheet. The process of sorting and weighing in households was carried three times in a week.

2.1.2 From the Community secondary collection points

The Mbeya City has about 126 community secondary collection points for solid waste (MCC, 2009). The sites include skip buckets, built enclosure and open piles. Four secondary collection points were identified based on the population around it. The solid wastes were thoroughly mixed up before the sorting sample was isolated. From the homogenized solid waste a sorting sample weighing 91- 136 kg was isolated for sorting (Alqader and Hamad, 2012). The materials were manually sorted into nine categories as done in the households.

Table 2: Definition of the material categories

Types	Description
Plastics	All plastic materials
Paper	Office paper, computer paper, magazines, glossy paper, waxed, paper, newsprint and corrugated
Organic waste	All biodegradable materials like food waste, fruits peels, plant trimmings and grasses
Glass	All glass materials like windows and mirror glass as well broken bottles and other containers
Metal	The waste originating from Ferrous (Iron, steel, tin cans, and bi-metal cans), aluminum and non-ferrous non-aluminum metals
e-waste	Electrical and electronic equipment such as mobile phones, batteries, TV, computer and computer accessories etc
Inert waste	Waste Rock, sand, dirt, ceramics, plaster, and bones
Textiles	Waste of clothes, carpets, pillows
Wood	The waste which include sawn timber, wooded boards, furniture

3.0 Results and Discussion

Figure 2 presents the solid waste composition at the households before taking to the designated community secondary collection points. The results show that, the dominant materials category in the waste is the organic waste which makes an average of 57%. This category of solid waste contributed by the daily food remains from the family meals, the fruits peels, vegetables, grasses and plant trimmings from gardens. Almost similar status was obtained from the solid waste in community collection points where the organic waste contributed by 56% as shown in Figure 3. The slight difference in composition between the two sites is accounted for by the fact that, the waste in households are well handled as 84% of the households use bags to store their solid waste, 14.6% use bins with proper covers and only 1.4% use bins without proper covers. Proper handling reduces the possibility of some solid waste being scattered by wind or scavenged by animals such as dogs and birds. At the designated community secondary collection points, waste are collected in skip buckets, in open piles or built enclosures. Such points are just left open allowing roaming dogs and vultures to scavenge, taking away some of the disposed organic waste. The results match with those obtained by Alqader and Hamad (2012) who determined the solid waste composition in

Gaza Strip and the composition of organic waste from the waste stream was 52%. The results also correspond to the findings obtained by Senzige, *et al.,* (2014) from which the organic waste composition found to be varying with socioeconomic status of the household. In low socioeconomic category it was 52.9%, middles socioeconomic category 57.7% and 70.1% in high socio-economic category.

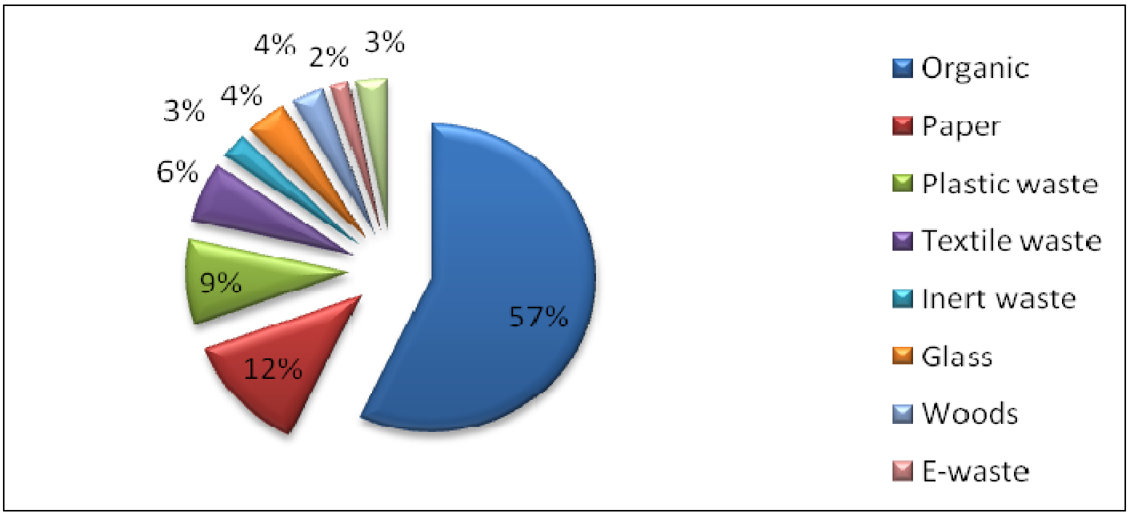

Figure 2: Percentage Composition of Solid Waste from Household

Woods and metals also showed a fall in average percentage composition between the waste in households and in the community secondary collection points as indicated in figure 3. In Tanzania Biomass-based fuel accounts for more than 90% of primary energy supply, where fuel-wood (charcoal and firewood), is the major source of energy to both urban and rural areas (URT, 2003). Woods are highly scavenged from any place including from dump sites. Other families sort out the woods before taking the waste to the secondary collection points. This also contributes to such fall in percentage composition of woods in solid waste, from an average of 3.3% in solid waste from households to 2.1% in solid waste at community secondary collection points.

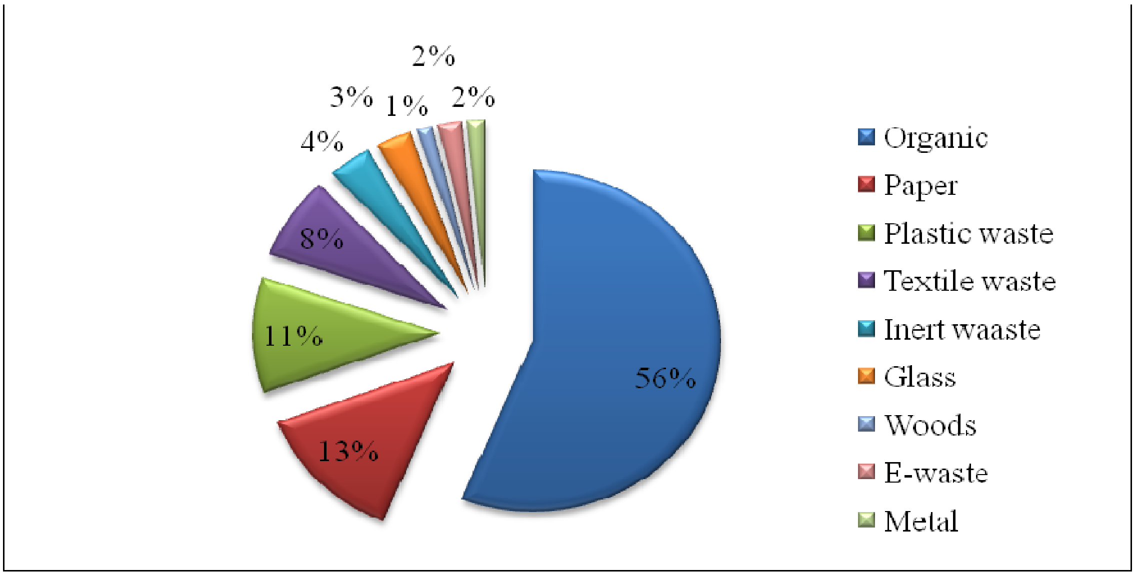

Figure 3: Percentage Composition of Solid Waste from Community Secondary Collection points

The results, also, show that about 9% of solid waste generated at the household level is largely plastic bags and bottles. This is largely caused by the lifestyles whereas most of the people in urban areas like Mbeya City use packed products such as juice, cooking oils, soft drinks, tomato and tooth paste, compared to rural areas. Plastic bags are widely used by retail consumers in carrying commodities from shops. These bags are cheaply obtained by customers from shops such that majority of them do not reuse as the result are mostly used once and disposed off. In community secondary collection points the percentage composition of plastics is (11%) higher than in households. This might be contributed by the fact that, in community secondary collection points, solid waste not only come from households but also comes from commercial places like shops. Although plastic materials are being scavenged and taken to industries for recycling, the scavengers collect only plastic bottles used for parking water, juice or soft drinks. Plastic bags are not scavenged for recycling making plastic among materials categories with high percentage composition in solid waste found in urban areas as indicated in Figure 4. However, increase in consumerization contributes to elevated levels of percentage composition of plastics in solid waste found in urban areas (Mato, 2002).

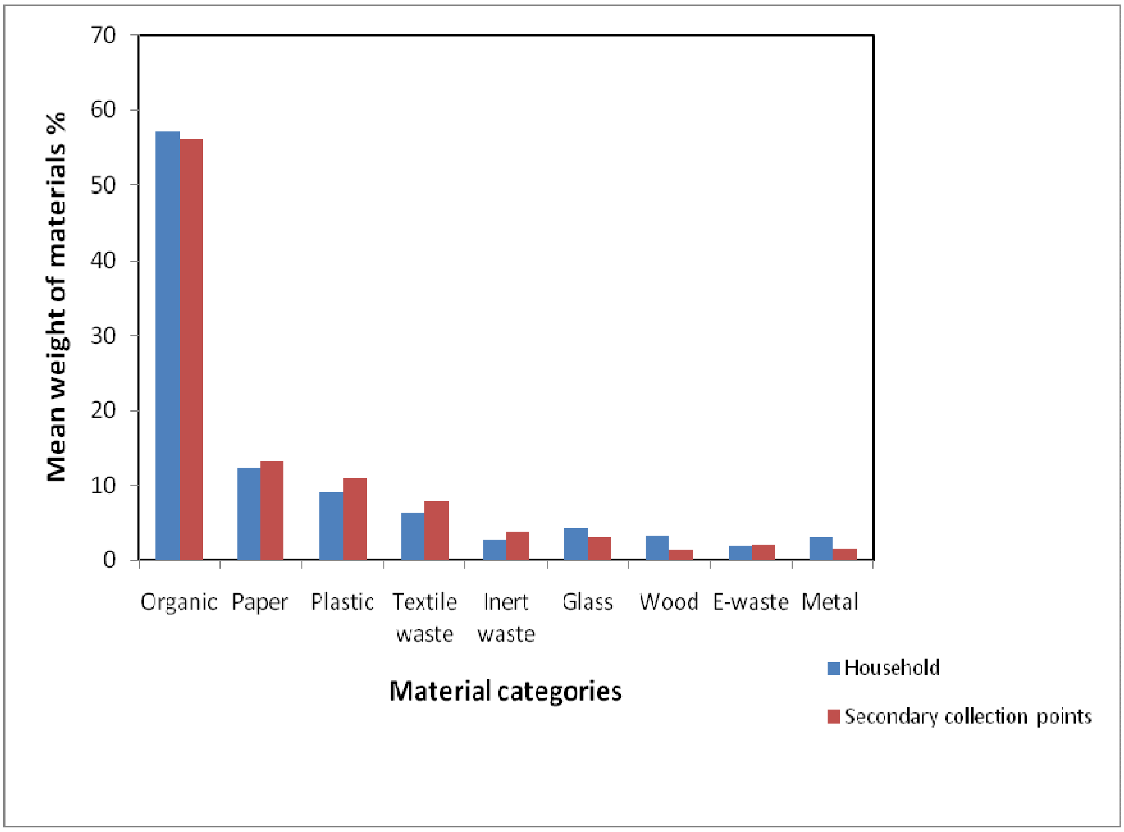

Figure 4: Percentage Composition by Material Category from Household and Community Secondary collection points

Inert materials are also making low percentage composition (3%) in household as construction and demolition take place very sporadically, moreover, construction and demolition waste are considered useful in ground leveling particularly in the eroded areas. However, the percentage composition of inert waste in community secondary collection points appears higher (4%) than in household as there are many sources contributing to that amount. Apart from households, there are some collected from commercial and institution centre where are also disposed at the same sites. The e-waste makes at least low proportion of about (2%) in solid waste from household and community secondary collection points. Previously the generation of e-waste materials in Tanzania was very low such that even some studies done on solid waste, did not considered them as a separate material category (Mato, 2002; Mlozi, 2011). Availability of e-waste indicates a wide use of e-products in the city resulting to the production of the identified waste. This makes an alert to all stakeholders in solid waste management to think about having sustainable ways of handling these e-wastes which normally have even traces of hazardous materials.

4.0 Conclusion

The study about solid waste composition in primary collection points and secondary collection points in Mbeya city indicated that organic waste is the major component with a proportion size of about 56% or 57% in solid waste from primary and secondary collection points respectively. Other material components include the paper (12% / 13%), plastic (9% / 11%), textile (6% / 8%), inert waste (3% / 4%), glass waste (4% / 3%), wood waste (4% / 1%) e-waste (2% / 2%) and metal (3% / 2%). The slight variation in percentage composition between the solid waste from primary and those from secondary collection points implies that, the system of solid waste management has no effect on the composition of the solid waste. Also the generated solid waste are not sorted or subjected to any treatment strategy at the household level. As large percentage of solid waste composition in household and secondary collection points accounted for by organic, plastic, and papers, it would be wealth while to encourage and officiate recycling and compositing. This will not only reduce the amount of solid waste disposed to the landfill, but also a strategy to recovery resource from the waste like organic fertilizer and other useful products.

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