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Original Research

Household Solid Waste Composition in Balakong City, Malaysia: Trend and Management

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Abstract

Waste is an obvious by-product that comes from human activities. Urbanization, economic development, and improving living standards in cities all have an impact on the increase of the quantity and difficulty of generated waste. Fast population growth and industrialization degrades the urban environment and places serious stress on natural resources. Inefficient management and disposal of solid waste is a noticeable cause of degradation of the environment in most cities of the developing world. MSW generation depends on township size and level of economic standards. Thus, it was proven by the MSW generated in the selected area of Kluang (a small town in the southern part of Peninsular Malaysia) amounted to as little as 45 tons and as much as 3,000 tons in Kuala Lumpur (Malaysia's capital). More analysis reported that the largest sources of MSW generation come from household waste, followed by industrial and commercial wastes. In Selangor State, the highest percentage of MSW consisted of putrescible waste of approximately 46%, followed by plastic and paper at 15% and 14%, respectively. This paper focuses on the trend and management of household solid waste composition generated in Balakong City, Malaysia. A survey for household residents in eight housing areas was carried out for one month and data were collected on a daily basis. The composition of solid waste collected was segregated into different components (organic waste, plastic, paper, glass, metal, and other). For overall household solid waste composition generated in the Balakong area, organic waste recorded the highest percentage at 555.5%. Then, followed by plastic waste 82.2%, paper 74.4%, other waste 42.9%, glass 25.8%, the lowest waste generated was metal at 18.9%. There is a relation between the economic position of a country and per capita waste generation rate. While the standard of living rises, waste generation rates also are increasing. The world trend of solid waste generation nowadays (including Malaysia) is mostly dependent on the changing consumption pattern, and also related to climate and seasonal differences. Thus, the management and planning of solid waste generated must be enhanced to improve sustainable solid waste management in Malaysia. Besides, public awareness, funding, expertise, equipment, and facilities that are currently lacking must be provided.

Keywords: municipal solid waste, waste composition, waste generation

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Introduction

Since the beginning of civilization solid waste has been produced. During the earliest periods, solid wastes were conveniently and unobtrusively disposed of in large open land spaces, as the density of the population was low. Today, however, one of the consequences of global urbanization is an increased amount of solid waste [1]. Rapid urbanization and industrialization changed the characteristics of solid waste generated. As a consequence, the solid waste management system (SWMS) needs to be updated to suit waste quality, quantity, and composition [2].

Basically, each developing country has its own characteristics of solid waste. Thus, the pattern of solid waste management differs from country to country and from city to city within a country due to technical differences, facilities, economics, social-cultural backgrounds, etc. Urbanization is becoming a global phenomenon, but its ramifications are more pronounced in developing countries. Natural growths of population, reclassification of habitation, and migration trends are important in urban populations [3].

In most developed and developing countries with increasing population, prosperity, and urbanization, it remains a major challenge for municipalities to collect, recycle, treat, and dispose of increasing quantities of solid waste and wastewater. A cornerstone of sustainable development is the establishment of affordable, effective, and truly sustainable waste management practices in developing countries [4]. Therefore, with increasing population, disposal problems become more difficult in urban areas. Simultaneously, there is greater production of waste per unit area and decreased proportion of land availability for its disposal. Many cities from Asian countries are facing serious problems in solid waste management [5]. Obviously Malaysia, as one of the developing countries, also has to deal with environmental problems and environmental pollution, especially related to solid waste generation. The amounts generated of the waste continue to increase in response to rapid increases in population accelerated urbanization and industrialization process [6]. The amount of solid waste management in Malaysia has put pressure on local authorities, making them continually seek new management strategies to deal with this waste generation that demands management, as well as find new sites for landfills, or supply management [7].

Municipal Solid Waste Generation and Composition

Municipal solid waste (MSW) is a term usually applied to a heterogeneous collection of wastes produced in urban areas, the nature of which varies from region to region. Therefore, solid waste composition is referred to every single type of waste composition usually in term of percentage unit. The characteristics and quantity of the solid waste generated in a region is not only a function of the living standard and lifestyle of the region's inhabitants, but also of the abundance and type of the region's natural resources.

Urban wastes can be subdivided into two major components: organic and inorganic. In general, the organic components of urban solid waste can be classified into three broad categories: putrescible, fermentable, and non-fermentable. Putrescible wastes tend to decompose rapidly and, unless carefully controlled, decompose with the production of objectionable odors and visual unpleasantness. Fermentable wastes tend to decompose rapidly, but without the unpleasant accompaniments of putrefaction. Non-fermentable wastes tend to resist decomposition and, therefore, break down very slowly. A major source of putrescible waste is food preparation and consumption. As such, its nature varies with lifestyle, standard of living, and seasonality of foods. Fermentable wastes are typified by crop and market debris.

Knowledge of quantity and composition of municipal solid waste (MSW) is fundamental for the planning of waste management systems. Most previous studies looked at the characteristics of municipal solid waste at the final disposal sites [8, 9]. With waste management strategies shifting toward more recycling, determining the quantity and composition of waste at the sources of generation is getting more attention [10, 11].

Waste Trend and Generation in Malaysia

Malaysia is located under a tropical country in southeastern Asia with a land area of 329, 847 km^2. As generally the country is separated into two regions (western and eastern Malaysia) by the South China Sea 12]. Malaysia generally possesses a tropical climate that is basically warm and humid throughout the year with temperatures ranging from 21ºC to 32ºC and a relative humidity of 80% to 90% [12]. The rate of waste generation in Malaysia is increasing, covering community activities such as commercial, institutional, industrial, and markets. It also is related to the economic level of different sectors in the community such as squatters, and low-, medium-, and high-class residential areas [13]. The rate varies according to the type of waste generators and land use. Depending on the economic status of the area, the per capita solid waste generation rate varies from 0.45 to 1.44 kg per capita per day [6].

Based on data produced by the Ministry of Housing and Local Government (MHLG, 2000) [14], the national average rate estimated for 1991 to 1993 was about 0.711 kg per capita per day. This average has been increased to 0.8 kg per capita per day from 1994 to 1999 and increased to 1.5 kg per capita per day in 2000. For the 2003, national average for waste generated per person is 4.5 kg per day. Data on solid waste composition was mainly on the physical characteristics [6]. Statistics gathered by the government indicated that the average amount of organic wastes for high income areas like Petaling Jaya and Kuala Lumpur was approximately 48.32%. This is followed by paper (23.56%), plastic and rubber (9.37%), metal (5.93%), wood (4.82%), glass and ceramics (4.03%), and textiles (3.97%). Generally, waste generation and composition vary with the degree of affluence and urbanization. Both the quantity and composition of solid waste vary widely from day to day and

Table 1. Waste generation in Peninsular Malaysia.

States	Population (2000)	Waste generated (2000)	Population (2001)	Waste generated (2001)	Population (2002)	Waste generated (2002)
Johor	2,252,882	1,915	2,309,204	2,002	2,366,934	2,093
Kedah	1,557,259	1,324	1,596,190	1,384	1,636,095	1,447
Kelantan	1,216,769	1,034	1,247,188	1,081	1,278,368	1,131
Melaka	605,361	515	620,495	538	636,007	562
N.Sembilan	890,597	757	912,862	791	935,683	827
Pahang	1,126,000	957	1,154,150	1,001	1,183,004	1,046
Perak	1,126,000	1,527	1,841,489	1,597	1,887,527	1,669
Perlis	230,000	196	235,750	204	241,644	214
Penang	1,279,470	1,088	1,311,457	1,137	1,344,243	1,189
Selangor	3,325,261	2,826	3,408,393	2,955	3,493,602	3,090
Terengganu	1,038,436	883	1,064,397	923	1,091,007	965
Kuala Lumpur	1,400,000	2,520	1,435,000	2,635	1,470,875	2,755

Source: Ministry of Housing and Local Government, 2003

also seasons of the year, not only between countries but also between neighboring localities and between different types of properties within the same town.

The handling and separation of wastes at the source is a critical step in waste management. The storage of waste at the source uses various types of bins such as a small bin (household), medium bin (communal bin), and large bin (hauled communal). The most-used bins for residential areas are small. Also, the bins used are of various materials, such as metal, plastic, rubber, concrete, and cardboard [15]. In the case of high-rise buildings, communal bins or a central container are used. Waste collection activities are the most expensive activity in waste management systems. The cost of waste collection consists of two types: direct and indirect. Direct costs include all direct expenditure incurred in the management of solid waste in an area. It also includes the resources used in the administration, development, and operations of waste management right from storage to collection, transportation, and disposal. Conversely, indirect costs refer to external cost incurred in practicing existing waste management systems. These costs include environmental damage costs of hazard storage, and collection disposal practices [15].

Information on the quantity of solid waste generated is fundamental to almost all aspects of solid waste management [16]. Most studies on MSW generation used the load-account analysis, which is based on waste collected and disposed of in the landfills. Changes in MSW generation rates are mostly caused by demographic factors and facilities, which are provided by the respective departments. Basically the solid waste quantities generated in urban centers are increasing due to the rise in the population and increase in the per-capita waste generation rate. The increasing solid waste quantities and the areas to be served strain the existing SWM system. Table 1 shows the relationship between population growth and solid waste generated in Peninsular Malaysia.

Malaysia's solid waste contains a high concentration of organic waste and consequently has high moisture content and a bulk density above 200 kg/m^3. A waste characterization study, Table 2, describes the main components of Malaysian waste such as food, paper, and plastic, which comprise 80% of overall weight.

MSW is normally disposed of by the landfill method or incineration. Only a small proportion of the MSW stream (about 2%) is recycled or treated by biological composting [16]. Furthermore, in Selangor all the MSW collected by the waste collectors is disposed of in an open dump landfill. The management of the landfill includes the monitoring and leveling of waste [17]. Many cities in Asian countries are facing serious problems in solid waste management. For instance, in India it is observed that more than 90% of MSW is disposed of on land without taking any specific precaution, which poses a serious threat to the environment [18]. This is supported by [1], who stated that in India, collection, segregation, transportation, and disposal of solid waste is inefficient and chaotic. Uncontrolled dumping of wastes on the outskirts of towns and cities has created overflowing landfills, which have a considerable environmental impact in the form of pollution to the soil, groundwater, and air, and also contribute to the global warming phenomena.

The planning of public waste collection services and MSW management in these developing countries are similar. This similar management pattern refers to negative aspects, such as the scarcity and insufficiency of planning, as well as non-scientific, disorganized, and informal MSW management. In addition, there are insufficient public and private funds and corrupt management of public sanitation systems [19]. Even though MSW management in developing countries is similar, the organization of the public waste collection service in developing countries is a major concern. This is reflected in the unknown quantity and type of MSW collected, the amount recovered and recycled, the

inadequate selection of final disposal sites, and inefficient reutilization and recycling programs [20]. In the absence of formalized waste segregation practices, recycling has only emerged as an informal sector using outdated technology, which causes serious health problems to waste-pickers [21].

Municipal Solid Waste Properties

Each MSW material has three main properties, namely physical, chemical, and biological [23, 24]. Information about the properties is important for planning a proper technology for solid waste treatment and disposal, because today, many solid waste management technologies involve recycling process, reuse, transformation, and waste disposal.

The first important property for municipal solid waste was physical properties. Physical properties of MSW include the specific weight (density), volume, and moisture content of solid waste. Specific weight is defined as the weight of material per unit volume. It normally varies with geographic location, season of the year, and length of time in storage. Besides that, physical properties also consist of particle size and distribution, capacity level, color, voids, optical property, magnetic property, and electrical property [25]. These properties are important in determining the waste volume collected, the compression needed, the selection of segregation equipment, and others.

Then, the second important property of MSW is chemical properties. It is very important in evaluating the alternative processing and recovery option such as proximate analysis, fusing point of ash, ultimate analysis (major elements), and energy content. The economic recovery of materials and/or energy often depends on the chemical composition of the solid waste – the individual chemicals as well as the heat value. Chemical properties measured for solid waste are moisture, volatile matter, ash, fixed carbon, fusing point, calorific value and carbon, hydrogen, oxygen, sulfur, and ash percentage [24].

Lastly, an MSW important property was biological properties. It is an organic fraction of MSW (excluding plastics, rubber, and leather) and can be classified as water-soluble constituents (eg: sugars, starches, amino acids and various organic acids), hemicellulose (eg: product of 5 and 6-carbon sugars), cellulose (product of 6-carbon sugar glucose), fats, oils, and waxes (eg: esters of alcohols and long-chain fatty acids), lignin, lignocelluloses, and proteins. The most important biological characteristic of the organic fraction of MSW is that almost all the organic components can be converted biologically to gases and relatively inert organic and inorganic solids. The production of odors and the generation of flies are also related to the putrescible nature of the organic materials [25].

Waste Management Application/Function

In the last two decades, MSW management has become a most important concern and is currently one of the major public subjects under discussion. This is perhaps outstanding to the significant increase of MSW generation in both absolute and per capita values. The quantity of MSW generated varies along with economic development and the claim for an efficient management solution [26]. In Malaysia, the population has been rising at a rate of 2.4% per annum, or about 600,000 per annum since 1994. Through this population expansion, the MSW generation also increases, which makes MSW management crucial [27]. Early solid waste management means digging pits (either temporary or permanent) or burying the refuse. Growing populations and increasingly urban lifestyles have made this practice untenable [28].

The management of solid waste in Malaysia has developed steadily. Municipal solid waste (MSW) management was quite primitive until the late 1970s. At that time the local district health offices cleaned only the streets and carried away the household wastes to municipal disposal sites that were assigned as authorized dumping grounds. Householders who did not have anywhere to bury their rubbish would throw it into the streets or watercourses, which impacted people's health. As a result, authorities were encouraged to introduce measures for the collection and disposal of solid waste, and it is the systematic structuring and institutionalization of solid waste management. In 2006 the daily generation of organic waste increased in Peninsular Malaysia from 13,000 tons to19,100 tons [29, 30]. The urban population, as in other countries in the world, generates more organic waste than the rural area population in Malaysia. The urban population has formed more than 65% of the total population in Malaysia [29], and it has been reported that municipal solid waste (MSW) generation in Malaysia has increased rapidly by more than 91% over the past 10 years. Waste in Malaysia is dominated by organic waste, which comprises more than 40% of the total waste stream.

In the 1980s and 1990s, the average organic waste was approximately 50% processed kitchen waste and food waste. While the generation of household waste increased, the frequency of collection also increased. In order to boost the efficiency of household waste disposal, the government of Malaysia hands over waste management to four private consortia. The privatization of urban solid waste management in Malaysia was started in 1993 with the objective of providing an integrated, effective, efficient, and technologically advanced solid waste management system. Although the waste management work was privatized, privatization in fact did not solve the problems [31]. The Malaysian government started conducting a few campaigns from time to time to make the people aware of environmental consciousness and the recycling process. For example, in 1988 the government introduced the Action Plan for a Beautiful and Clean (ABC) Malaysia, and recycling campaigns. These campaigns were successful and continued for several years. These campaigns also show that the government was able to create environmental awareness and knowledge of waste management among the public to a satisfactory level. A survey carried out in 1999 showed that 59% of respondents were moderately aware with some basic knowledge, and were mildly alert to the management of solid waste [32]. The campaign for recycling and reuse of waste materials should continue to bring a good outcome in the future.

Solid Waste Management Policies and Public Cleansing Act (2007)

Most developing countries do not have specific policies on solid waste management. Some of the reasons for this include: lack of interest or resources, the environmental and public health standards are too high to be realistically reached, inadequate capabilities of the designated responsible institutional organization, responsibilities not clearly defined, lack of trained professionals and managerial skills, and the absence of motivational and educational programs for industry and the public [33]. Basically the importance of specific policy for solid waste management is to provide future directions for all aspects of solid waste management, for example from storage, collection, transfer and transport, treatment and disposal. In Malaysia, the ABC plan prepared by the Ministry of Housing and Local Government in 1988 has become a factor guideline for solid waste management activities by state and local authorities. The ABC Plan describes the need for a national policy, its objectives and components, the roles of the various levels of government and private sector, and finally provides comprehensive action plans with clearly identified program [34].

The Solid Waste and Public Cleansing Management Act came into force on 1 September 2011. Starting from that the government, concessionaires, and the public are now components of a new beginning in the country's effort to manage solid waste efficiently. This new legislation may possibly cover the way for a holistic transformation that the public has desired for all this while and is in line with Malaysia's goal of emerging as a developed nation.

Under this new Act solid waste management is under the federal government (privatization) and no longer the local governments as before. In addition, to ensure that ideal results are achieved, strict key performance indicators (KPI) are required of the concessionaire. Then, service areas for solid waste management were classified into three zones with different companies managing their waste. Therefore, service areas for solid waste management were classified into three zones with different companies managing their waste. Alam Flora Sdn Bhd is responsible for waste management in the central and eastern region of Peninsular Malaysia. Southern Waste Management (SWM) Sdn Bhd is responsible for waste in Melaka, Negeri Sembilan, and Johor, while Environment Idaman Sdn Bhd covers the whole area of Kedah and Perlis. The Solid Waste Management Act is not enforced in Sabah and Sarawak, as both states have their own set of laws to regulate solid waste management and public cleanliness [35].

Methodology

The study was carried out in Balakong Area, between Sri Kembangan and Pekan Batu 9, Cheras because it consists of several household areas, industrial areas, and one hypermarket. Based on the map given by Majlis Perbandaran Kajang (MPKJ) and analyzed from Malaysia's Department of Statistics, the area of studies consist of 4,433 residents [36] based on a map of Blocks of Population and Housing Census of Malaysia 2000. Therefore, solid waste composition generated by households, industries, and hypermarket

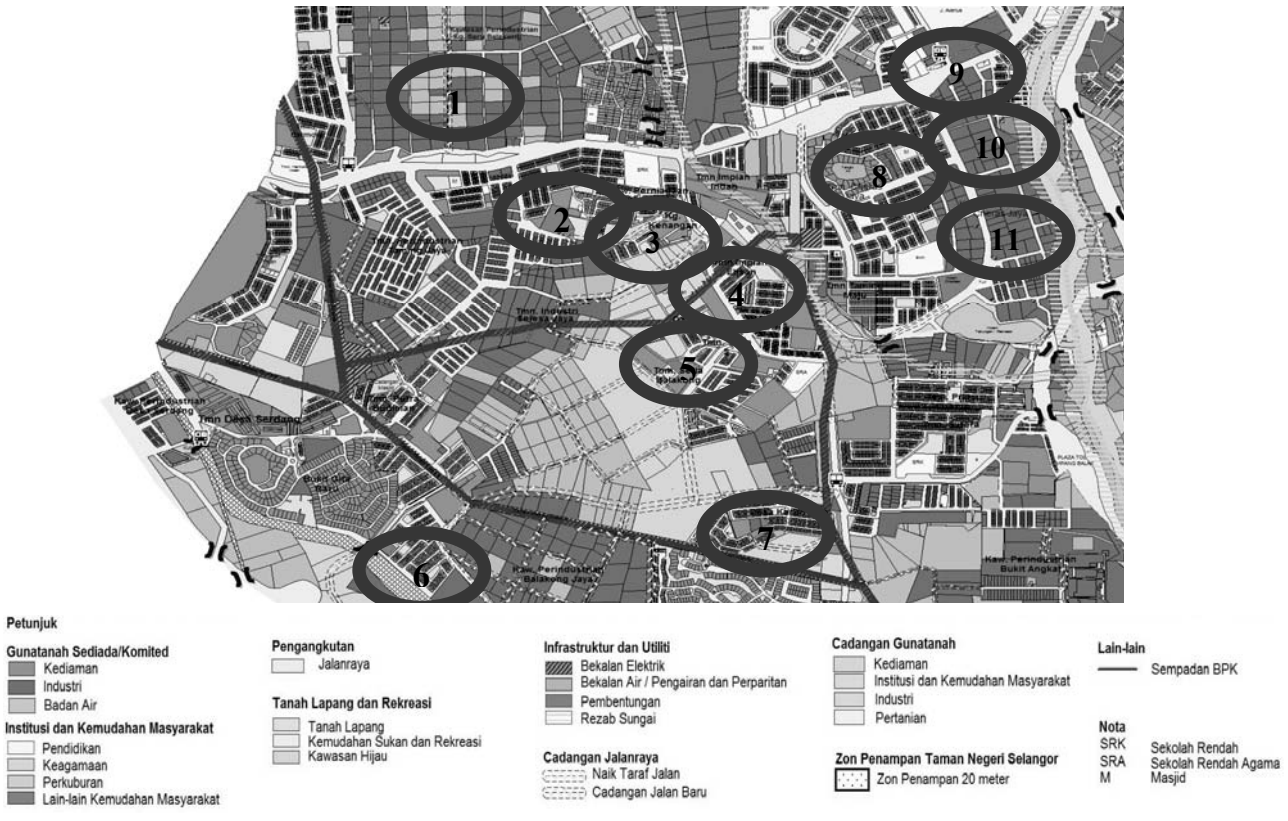

Fig. 1. Land use map of the Balakong area.

Table 2. Solid waste composition generation for a household in Balakong City for one month.

Accumulative data of solid waste generated (Kg/month/household)							
Source location	Organic waste	Paper	Plastic	Glass	Metal	Other	Total
Taman Balakong Jaya	532.50	78.05	63.81	19.45	8.82	23.49	726.12
Taman Taming Jaya	710.40	76.20	79.00	2.20	3.90	63.00	934.70
Taman Sri Indah	627.45	61.90	72.58	22.07	11.15	33.59	828.74
Taman Cheras Jaya	1016.08	183.41	198.88	89.02	89.40	99.98	1677.0
Kampung Kenangan Indah	612.60	88.60	174.70	6.10	5.00	80.80	967.80
Taman Impian Ehsan	942.00	96.15	67.71	51.35	24.87	36.23	1218.31
Taman Setia 2	427.00	40.20	48.45	12.60	17.30	35.85	581.40
Taman Desa Karunmas	475.97	111.40	105.65	66.98	43.30	46.00	849.30

can be studied. Fig. 1 shows the land use map of Balakong, and the area circled in grey is the selected area for this study. Before the research was conducted, the information concerning waste generation and its quantity and disposal management was necessary. For this reason, a few site visits and personnel observations were carried out to choose a suitable study area, which is the residential area. Then, an interview was conducted and official letters regarding this study were given to obtain permission from the owner of the building (household).

For this study, data were collected from 23 January to 21 February 2012. Because of Malaysia's weather conditions, for household areas the data were mostly taken in the evening or in the early night. Before that, for household areas, plastic bags were given to respondents for each house on 19 and 20 January. Each participating household was issued with 60 plastic bags, two for each day for 30 days. One plastic bag was used to deposit their daily wet waste, and another for dry waste. Wet waste mainly consisted of food and organic waste, while dry waste were the other composition, such as paper, plastic, metal, glass, and other. All solid waste generated from respondents by three different areas were weighed by balance with a scale from 0 to 50 kg. There were six solid waste compositions involved in this study: organic waste, paper, plastic, glass, metal, and other.

Results

The study on the municipal solid waste (MSW) composition in eight selected housing areas in Balakong City was carried out for one month duration and data were collected on a daily basis. Municipal solid waste can be classified by source (household, commercial, institutional, and selected industrial waste), composition (organic, inorganic, and recyclable) and lastly chemical and physical characteristics (density, moisture content, etc.) [37]. Table 2 presents the accumulative data of solid waste generated in all eight different areas. The amount of the total separated waste was distinguished by six categories.

The data from Table 2 showed that Taman Cheras Jaya has the highest amount of waste composition generated, which is 1,677 kg/month. From the total weight, organic waste contained the highest portion, which is about 1,016.1 kg. At Taman Cheras Jaya glass and metals contributed the smallest amount of waste generated, with a value of 89.02 kg and 89.4 kg, respectively. However, in Taman Setia 2, the total waste generated for a month is only 581.4 kg and is the lowest among all the housing areas selected in this study. Organic waste makes 427.0 kg of the total waste generated in Taman Setia 2, while the two lowest waste composition values belongs to metal (17.3 kg) and glass (12.6 kg).

From Table 2 the data was transformed into a bar graph (Fig. 2) to give a clearer view on the data of solid waste generated in all eight different areas. The blue bar represents organic solid waste, which showed clear differences between all the colored bars. This is because organic waste monopolizes the high value of waste generated in Balakong areas. Then, from the data value in Table 2 the percentage of household solid waste composition generated in Balakong City was calculated. Table 3 shows the details of the percentage value of solid waste composition generated.

Table 3 shows the percentage of solid waste composition generated by the household in the housing areas in Balakong City for 1 month. Organic waste stated the highest composition value compared to other solid waste generated in eight housing areas. At Taman Impian Ehsan, it recorded the highest percentage (77.3%) and the lowest percentage of organic waste (56.0%) at Taman Desa Karunmas. Besides that, Taman Desa Karunmas has the highest percentage of paper (13.1%) while the lowest percentage belongs to Taman Setia 2 (6.9%). For plastic, the highest percentage is found in Kampung Kenangan Indah (18.0%) and the lowest plastic percentage is found in Taman Impian Ehsan (5.6%). Taman Desa Karunmas was shown to have the most abundant amount of glass waste due to its highest percentage (7.9%), and Taman Taming Jaya recorded the lowest glass waste percentage with only 0.2%. For metal, the highest percentage belongs to Taman

Table 3. Solid waste composition generation of household in percentage for Balakong City in one month.

Composition (%)							
Sources location	Organic waste	Paper	Plastic	Glass	Metal	Others	Total (%)
Taman Taming Jaya	75.9	8.1	8.4	0.2	0.4	6.7	100
Taman Balakong Jaya	73.3	10.8	8.8	2.7	1.2	3.2	100
Kampung Kenangan Indah	63.3	9.2	18.0	0.6	0.5	8.3	100
Taman Sri Indah	75.7	7.5	8.8	2.7	1.4	4.1	100
Taman Impian Ehsan	77.3	7.9	5.6	4.2	2.0	3.0	100
Taman Setia 2	73.4	6.9	8.3	2.2	3.0	6.2	100
Taman Cheras Jaya	60.6	10.9	11.9	5.3	5.3	6.0	100
Taman Desa Karunmas	56.0	13.1	12.4	7.9	5.1	5.4	100
Total (%)	555.5	74.4	82.2	25.8	18.9	42.9	100

Cheras Jaya (5.3%) and the lowest goes to Taman Taming Jaya (0.4%). Lastly, Kampung Kenangan Indah was found to have other types of waste with a percentage of 8.3%.

Strategic Solid Waste Management of Waste Generated in Balakong City

Basically, we all desire to reflect on the past at the end of our lives and say to ourselves that we had a good life. The term "life cycle" is one method to sustain the resources or in other word refer to the time between birth and death, and evaluating a life cycle assessment. Just like our lives, products that enrich our lives should also contribute to saving resources without producing negative environmental effects [38]. To ensure this, methods have been developed to evaluate the life history of a product, for example the time between its creation and disposal also compares products in terms of their environmental effects, especially in Balakong City. A typical example would be comparing paper diapers and cloth diapers. Since it is easy to use and convenient paper, diapers generate an enormous amount of waste. Some people believe that these product are causing serious environmental problems. However, a product life cycle assessment (PLCA) shows that contrary to our expectations, for these reason, cloth diapers, whose use requires the consumption of a large amount of water and electricity and produces sewage to be treated, may have greater negative effects on the environmental than paper diapers.

Waste Life Cycle Assessment (WLCA) for Choosing Measures and Technologies

Thus, proposals are often made to use various measurements and technologies in order to make improvements in current waste management. But do such proposals really lead to improvement? It is becoming increasingly difficult to secure sites for final waste disposal and build incineration plants such as in Balakong City. Conversely, there is a

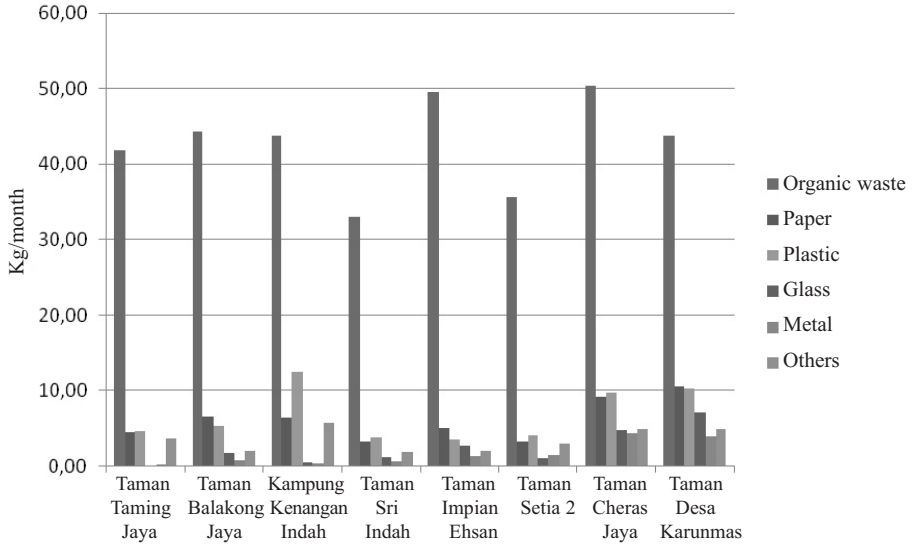

Fig. 2. Differences in average solid waste generated by household in housing area for 1 month.

wider range of waste disposal measurements and technologies available for local communities than before, including economic (such as recovery by manufacturer and changing fees for waste) and the use of recycling facilities (including screening facilities for recyclable waste and crushing facilities for bulky waste and regional waste disposal). There are differences between local governments in terms of the choices available. For example, in local communities where final disposal sites are not available, incineration ash is used as cement material or turned into molten slag to avoid landfilling. Evaluating whether an improvement proposal really leads to improvements entails makingan necessary quantitative assessment of resources, energy consumption, and environmental impact for a series of waste management process ranging from collection, transportation, and treatment to final disposal as the WLCA process in Fig. 3.

Discussion

The data from Table 2 show that Taman Cheras Jaya has the highest amount of waste composition generation with the value of 1,677 kg/month. The waste generations will continuously rise up every year due to the uncontrollable consumption owing to the increasing population, attitudes toward shopping and eating, and the high living standard. From the total weight, organic waste comprises the highest portion, which is about 1,016.1 kg, while glass and metals contribute the smallest amount of waste generated (89.02 kg and 89.4 kg, respectively). The highest amount of organic waste in Taman Cheras Jaya is engaged by kitchen waste and other inseparable material. It can be assumed that each house at Taman Cheras Jaya has many family members so this means they consumed a lot of kitchen waste. A different picture is depicted in Taman Setia 2, whereby the total waste generated for a month only 582 kg, the lowest among all the housing areas selected in this study. Organic waste makes 427.0 kg of the total waste generated in Taman Setia 2, while the two lowest waste composition values belong to metal (17.3 kg) and glass (12.6 kg). Based on the results, the MSW generated in Balakong contains a good potential of recyclable components. But unfortunately the attention paid by the authority toward this direction is not sufficient to tackle this issue [39].

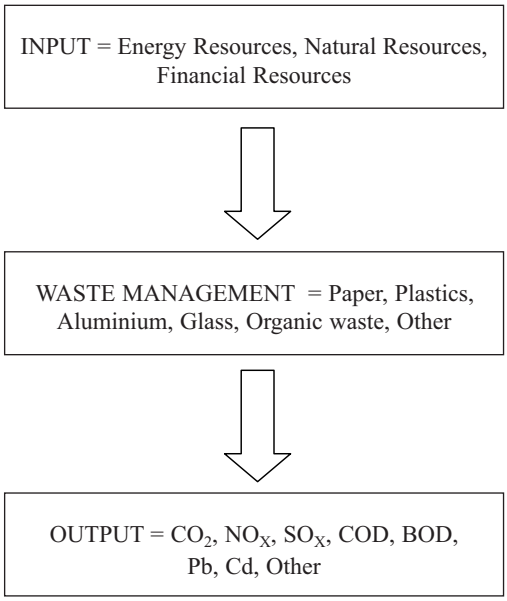

Fig. 3. WLCA flow model.

Table 3 shows the percentage of solid waste composition generated by a household in Balakong City for 1 month. As predicted, organic waste was the highest composition among all solid waste generated in eight housing areas. Taman Impian Ehsan shows the highest percentage (77.3%), and the lowest percentage of organic waste (56.0%), which belongs to Taman Desa Karunmas. These are typical variations between the percentage of organic waste composition and other type of waste. Taman Desa Karunmas has the highest percentage of paper (13.1%) while the lowest percentage belongs to Taman Setia 2 (6.9%). For this reason, the assumption for this condition to happen is because the households in Taman Desa Karunmas produced a lot of paper due to their daily routine. As for plastic, the highest percentage is found in Kampung Kenangan Indah (18.0%) and the lowest in Taman Impian Ehsan (5.6%). Plastic and paper composition in household waste was the second and third highest, which might be due to changes of the household lifestyle, which prefers to buy a variety of ready-made foodstuff in packages and reading materials [40]. Taman Desa Karunmas was shown to have a plentiful amount of glass waste due to its highest percentage (7.9%). A different story goes to Taman Taming Jaya, which has the lowest glass waste percentage with only 0.2%. For metal, the highest percentage belongs to Taman Cheras Jaya (5.3%) and the lowest percentage goes to Taman Taming Jaya (0.4%). Lastly, Kampung Kenangan Indah was found to have 8.3% of other types of waste. Metal wastes were not often found in household waste because the community starts to practice the recycle attitude. Based on supply and demand theory of recyclable materials, the market price is changeable [39]. The potential higher demand is on mixed paper, mixed plastic, and aluminum. But today their costs per kg are roughly RM0.25, RM0.20, and RM0.50, respectively. All the metals usually sold for recycling because of high price offered is about RM2.5/kg compared to plastic and paper at RM0.45/kg and RM0.1/kg, respectively [41].

Conclusion

The results of solid waste composition generated in Balakong City showed great variability between the waste compositions. In Malaysia, the efficient planning and management of solid waste is the responsibility of local government, including urban cleansing and services. Inefficient management of solid waste has a negative impact when pollution from solid waste occurs. Without systematic management people will be confronted with problems related to the environment, human health, and social issues. Integrated solid waste management in Malaysia is a man-

agement system standing on the hierarchy of waste management. The hierarchy aims to optimize the management of solid waste generated from various sectors (household waste, commercial waste, institutional waste, industrial solid waste, solid waste, and public construction waste) involving all stakeholders and community. The world trend of solid waste generation nowadays, including Malaysia, mostly depends on the changing consumption pattern, and also relates to climate and seasonal variation. As a result, the management of solid waste generated must be improved to ensure that the technology used is suitable with current solid waste development. Therefore, to improve sustainable solid waste management in Malaysia, public awareness, funding, expertise, equipment, and facilities that are currently lacking must be provided.

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