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SOLID WASTE MANAGEMENT IN SHAH ALAM CITY RESIDENTIAL AREA

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Abstract: Growth in population, increasing urbanisation, inadequate infrastructure, rising standards of living and rapid development in technology are some of the major factors that have influenced directly the municipal solid waste generation in Malaysia. Municipal Solid Waste Management is a problem and a serious challenge to local government authorities in developing countries. In Malaysia, the total quantity of municipal solid waste generated is projected to increase from 19,100 tons of waste per day in 2005 to 30,000 tons per day by 2020, with the annual population growth rate of 2.5 per cent. Practicing solid waste minimisation is one of the ways of reducing solid waste generation. This paper reviews: (i) the current practices in solid waste management and the trends of municipal solid waste generation and composition in Malaysia and (ii) solid waste management practices in Shah Alam City Hall, Selangor, Malaysia, and the current challenges. Through a longitudinal survey that lasted for 14 days, wastes generated by 100 households were collected and analyzed in an effort to characterize household solid waste generation and composition. Results showed that 0.43kg of solid waste per person/per day was generated which translates to 372,737.76kg for the entire Shah Alam city. In terms of composition of wastes generated by households, findings from the study showed that organic waste constitutes 33.98% of the total waste, recyclable materials (45.51%), and non-recyclable materials (20.51%). Our study found some flaws in the current waste management practice due to lack of public awareness, inadequate waste management plans, lack of proper recycling infrastructure and management by the local authority. The current waste minimisation system in Shah Alam is ineffective; therefore, the local authority should introduce at-source separation techniques as part of waste management practice.

Keywords: Municipal solid waste management, solid waste generation, solid waste minimisation.

Introduction

Solid wastes are materials not used which need to be removed from residential, commercial, institutional and municipal areas. The generation of solid waste is an important by product of socio-economic activities. Solid waste management (SWM) has become a major problem for many due to complexity involved in collection, separation, recycling and final disposal countries. Presently, waste is generated faster than other environmental pollutants, including greenhouse gases (GHGs) (Hoornweg *et al.,* 2005), water pollution as well as diverting the waste from landfills and incinerators (Agarwal *et al.,* 2005). Lack of proper management of municipal solid waste (MSW) is a serious environmental problem in Malaysian cities. Efficient SWM system is now a global concern for a sustainable SWM. As far as environmental friendliness is concerned, recycling activities make significant positive influence by preventing greenhouse gas emissions. Currently, solid waste minimisation activities are not optimally practiced. This paper reviews: (i) current practices of SWM and the trends of municipal solid waste (MSW) generation and composition in Malaysia and (ii) SWM practices in Shah Alam City Hall (MBSA), Selangor, Malaysia, and the existing problems.

Solid Waste Management Systems

Solid waste management (SWM) is defined as the control of waste generation, storage, collection, transfer and transport, processing and disposal consistent with the best practices taking into consideration public health, financial, legal and environmental implications. Solid waste minimisation is the process of reducing the amount of waste in streams. The important concept of waste minimisation is through 3R's (Reduce, reuse and recycling) (Franchetti, 2009) and treatment (composting and incineration) (Schall, 1992). Solid waste minimisation hierarchy incorporates the concept of reducing solid waste in streams. The process involves six steps ranked according to environmental impact. Reducing, which offers the best outcomes for the environment is at the top of the priority order, followed by preparing for reuse, recycling, composting, incineration and disposal. The treatment concept is in turn better than disposal to landfill. Figure 1 show the pyramid of waste minimisation, where reduction is the most preferred option while the landfill is seen as the least favoured option.

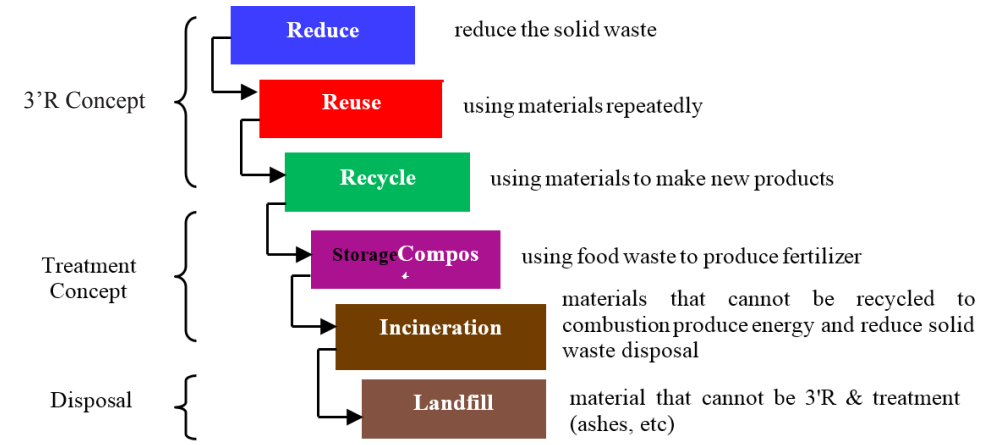

Figure 1: Pyramid of Waste Minimisation

The 3R's concept is one of the ways of minimising the amount of solid waste for final disposal. Waste reduction is first in the hierarchy of solid waste management and is a difficult alternative compared to recycling. In the housing area, households must reduce the amount of municipal solid waste being produced. They need to imbibe such attitude like bringing their own bags to shopping, using the tool replenishment of buying new containers, using cloth diapers, using rags rather than tissue paper and others that can reduce the waste from waste stream, (Worrell & Vesilind, 2012). Reuse of items means that materials are still useful and have utility or value for more than one purpose instead of throwing them away. Households can reuse or give them to others who need it, rather than throw away in waste stream to reduce the waste generation (Worrell & Vesilind, 2012). Recycling is the process of separating out the waste materials that are useable for recycling so that they can be collected separately from the rest of the solid waste. The recycling materials are glass, plastic, paper, cardboard, and others that can be used for the manufacture of new products (Worrell & Vesilind, 2012).

Treatment is the last option for reducing solid waste from waste stream. Composting is one of the treatment concepts for reduction technique that can divert large volumes. Composting only focuses on food and home

waste. Incineration can be defined as a process of controlled combustion for burning solid waste (solid, liquid and gas). In this process, carbon, hydrogen and other elements in the waste are combined with oxygen in the combustion air which generates heat.

Best Practice of Solid Waste Management

An important factor is the absence of source-sorting techniques in the waste management practices in the study area. In contrast, in developed countries like Japan, households have proper at-source sorting techniques, and the public are encouraged to sort their wastes at source.

Solid Waste Management in Japan

Japan has the highest level of sustainable waste management (Nickolas & Charles, 2014). It generates on a yearly basis about 65 million tons, of which it treats 40 million tons thermally. The rest is recycled or composted, and only 2% goes to landfill. Japan can be considered as a leader in developing and implementing traditional and novel thermal treatment technologies. Housing waste generation can be controlled at source by households where the waste originates. To improve waste reduction at source, the local governments prepared flyers and handbooks that explained in plain language and using illustrations how to sort and put out waste, and these were then distributed to households in order to promote their understanding of sorted waste collection. Local government staff gave demonstrations using plastic containers and packaging to meet the needs of individual residents. There are three main types of garbage that must be separated completely from each other: burnable, non-burnable, and recyclable. Municipal authorities collect domestic waste as well as bulky refuse discharged from households. The transfer station method most commonly adopted in Japan is the compactor container transfer station. Waste collected by small garbage trucks is dropped into a hopper, compressed in containers, and reloaded into larger trucks. In transfer stations, two tons of waste can be compressed into one container. The container is then transported to a disposal site or incineration plant on a large container truck (Ministry of the Environment, Japan, 2012).

Japan is renowned as having the most advanced waste incineration plant technology. With Japan's high-technology incineration facilities, waste incineration has won consumers trust as a safe and efficient technology. The facility was constructed using high technology with a capacity of 200 tons per day, which satisfied the strict regulations for gas emissions, such as smoke, dioxin and other gases. The power generation capacity attained 1,515 megawatts (MW) and actual power generation was 7,050 gigawatt (GW) h/year (Takaoka *et al.,* 2011). Recycling companies are assigned to collect and transport the waste from the storage sites to recycling facilities. Combustible household waste, incombustibles, used batteries, and spray cans are collected on the same days twice a week. Cans, bottles, PET bottles, and small metal items are collected on a different day once a week. Containers and packaging are collected on another day once a week. Old clothes and used papers are collected twice a month. Bulky waste is collected upon request. Japan adopted the 3R's to encourage environmentally sound waste management and resource efficiency in the mid-1990s. The waste materials are typically released according to a sorted order at collection points for a number of households and then gathered by the municipality, a private company, or group collectors on different days according to particular categories of waste. Therefore, the source separation campaign in this country was a success and achieved a high recycling rate compared with that of other countries. Japan also passed the Law for the Promotion of Sorted Collection and Recycling Containers and Packaging in 1995, thus driving municipalities to collect recyclable resources.

Solid Waste Management in Malaysia

Malaysia is located in the continent of Asia with a total land area of 329,847 square kilometres, making it the 67th largest nation in the world

(Worldatlas, 2012). Recycling has been in practice in MSWM in Malaysia since the 1980's. However, in 2011 this was incorporated by every local authority (LA) in the country. Generally, in the context of Malaysia, household solid waste management (HSWM) begins from the waste generated. After that, the next stage is waste collection and transfer to the station before proceeding into treatment/separation phase. Solid wastes that are not reusable are disposed into the landfill while those can be recycled are treated. SWM system practiced in Malaysia is quite similar to that in developed countries. Solid waste generation in Malaysia rose from 2.5-3% annually between 2006-2010 (Zainal *et al.,* 2002). Rapid rate of population growth and increasing wealth among the citizens, is expected to increase the percentage. In Peninsular Malaysia, the total quantity of MSW generated is expected to increase from 19,100 tonnes of waste per day in 2005 to 30,000 tons per day by 2020, with population growth of 2.5 per cent (Nazeri, 2002). Based on data provided by the Government of Malaysia in RMK9, the average per capita generation of MSW rate increased from 0.67 kg/capita/day in 2001 to 0.8 kg/capita/day in 2005 (RMK9) and this amount is expected to increase to double digits in line with the population growth by the year 2020 (Hassan *et al.,* 2001).

The details of average growth rate of MSW generated in Peninsular Malaysia by state are shown in Table 1. This clearly shows that the average growth rate of MSW generation in Malaysia increased by 3.18 percent from 2000 to 2010. The quantity of waste generation in Selangor alone was projected to increase from 1,250,000 tonnes per day in 2000 to 1,617,000 tonnes per day in 2010. Selangor shows the highest rate of solid waste generated at 1,617,000 tonnes (3.04%) compared to 1,456,000 tonnes in Johor (4.49%) and Kuala Lumpur 1,205,000 tonnes (1.14%) in 2010. This was due to the total population of the state of Selangor, Johor and Kuala Lumpur increased from year to year. This clearly indicates that the quantity of MSW in Malaysia has increased dramatically. Thus, an efficient management system of MSW is needed in order to avert environmental and health problems associated with MSW.

Table 1: Solid waste generation in Peninsular Malaysia by state (in '000 tonnes) (Source: DSM, 2000 & MHLG, 2010)

States	Population 2000	SW Generated 2000	Population 2010	SW Generated 2010	Average Growth rate (population-%)	Average Growth rate (solid waste-%)
Kuala Lumpur	1,379,300	1,082	1,674,621	1,205	2.14	1.14
Selangor	4,188,900	1,240	5,462,141	1,617	3.04	3.04
Pahang	1,288,400	210	1,500,817	252	1.65	2.00
Kelantan	1,313,000	120	1,539,977	120	1.73	-
Terengganu	898,800	125	1,035,977	157	1.53	2.56
N. Sembilan	859,900	291	1,021,064	427	1.87	4.67
Melaka	635,800	225	821,110	322	2.91	4.31
Johor	2,740,600	1,005	3,348,283	1,456	2.22	4.49
Perlis	204,500	29	231,541	34	1.32	1.72
Kedah	1,649,800	631	1,947,651	977	1.81	5.48
Pulau Pinang	1,313,400	648	1,561,383	844	1.89	3.02
Perak	2,051,200	763	2,352,743	996	1.47	3.05
Total	18,523,600	6,378	22,497,308	8,407	2.15	3.18

Note:

Estimated only based on the population and solid waste generated (2000 & 2010).

The composition of MSW is closely related to the level of economic development and lifestyle of the households. In Malaysia, the average components of MSW are quite similar with the largest categories consisting 49.3% of food waste (organic waste), followed by 17.1% paper, plastic and iron with 9.7% and 1.6%, respectively, and 22.3% of other waste (RMK9). Generally, the most obvious solid waste composition in Malaysia is highly organic waste and consists of biodegradable and non-biodegradable waste. Detailed composition is shown in Table 2. The characteristics of MSW components also play important role in determining the suitability of the disposal systems. Food waste is the highest component of solid waste every year between 37 - 68%. This shows that the authorities should increase more dynamic composting methods for the disposal of solid waste. In addition, recyclable materials also show a high percent (29 - 57.4%) of the solid waste component and authorities should take measures to reduce waste through the concept of 3R's and others. Furthermore, for non-recyclable, special and hazardous waste there is need to identify the most suitable alternative for long term solutions to reduce the burden of existing MSW disposal systems (ie, sanitary landfills and dumping sites). Storage of waste generated by households can be divided into two phases. In the first phase, solid waste is stored outside of the house in their storage bin until it is collected by the waste collectors. For the landed property owners, they are compulsory to purchase a suitable waste bin from the local authorities at a reasonable price. Besides that, properly designed bins are provided to premises and residential areas like apartments and illegal settlements. There are also some households who drop the recyclable materials at a recycling centre. However, segregation of recyclable waste is not much practiced by the Malaysian household (Goh, 2007). Waste collection is operated by private collectors which have to register their company, including the facilities used with the LA. In Malaysia, more than 80% of the MSW are collected (Nadzri, 2012). Transfer station functions as transit, waste collection centres leading to the landfill sites. Large trucks suited for long journey are used to transfer the waste to final disposal site rather than smaller ones used for house-to –house collection. Moreover, the Malaysian government is now considering the usage of incinerators. An incinerator is able to incinerate 5 to 10 tons of solid waste per day (EASUR, 1999).

Table 2: Malaysian Solid Waste Composition (Source: Hassan *et al.,* 2001, W.A. Kadir, 2001, Nazeri, 2002, Kathirvale *et al.,* 2003, JICA, 2006, MHLG, 2005, Eusuf *et al.,* 2007, Yatim & Arshad, 2010, Chua *et al.,* 2011).

Types of waste	Waste Capability	Components	2001	2002	2003	2004	2005	2007	2010
	Composting / biodegradable	Food waste & organic	68.4	56.3	37.4	49.3	47.5	42.0	43.5
Organic wastes	Recyclable / non-biodegradable	Mix plastic	11.8	13.1	18.9	9.7	-	24.7	25.2
		Mix paper	6.3	8.2	16.4	17.1	18	12.9	22.7
		Textiles	1.5	1.3	3.4	-	2.1	2.5	0.9
		Rubber & Leather	0.5	0.4	1.3	-	-	2.5	-
		Wood	0.7	1.8	3.7	-	4	5.7	-
		Yard wastes	4.6	6.9	3.2	-	2.7	-	-
	Non-Recyclable / residual waste	Pampers	-	-	5.1	-	3.8	-	-
In-Organic wastes	Recyclable / non-biodegradable waste	Aluminium	-	-	-	-	-	-	1.2
		Ferrous	2.7	2.1	2.7	2.0	-	5.3	2.1
		Glass	1.4	1.5	2.6	3.7	-	1.8	2.6
Special & Hazardous wastes		Other	2.1	8.4	5.3	18.2	21.9	2.6	1.8
Total			100	100	100	100	100	100	100

Treatment and recycling methods should be incorporated in SWM because of the government's target of 40% waste reduction to landfill by 2020 (Nadzri, 2012). Solid waste minimisation must be increased in order to achieve that goal. The situation of MSWM in Malaysia is similar to other Asian countries. Managing the waste had taken a big chunk of the nation's expenditure. The urban areas in Asia spend about US$25 billion (RM87.25 billion) on SWM per year and this figure will increase to at least US$50 billion (RM175 billion) in 2025 (EASUR, 1999). The waste flow in Figure 2 shows the flow of SWM in Malaysia from household generation to disposal sites. The current rate is about 11% (Nadzri, 2012), and is expected to rise to 18% (Chong et al., 2005). The national target for waste minimisation in year 2020 is 22% (RMK9). Currently, it is 11% and we are left with only about 4 years to achieve the target. Malaysia is really far behind the targets set (refer to Table 3).

In the developing countries, municipalities usually lack recycling programmes but that does not mean that recycling does not exist. When looking at the two scenarios, it is clear that there are basic underlying differences between their operations and the policies by each country. In developed nations, there are generally positive attitudes towards recycling because it is considered a social norm, in contrast with developing countries where they still practice resource recycling. It is imperative that both developed and developing countries realize that increasing environmental knowledge and behaviour are key in increasing solid waste minimisation. Table 4 compares solid waste management between Malaysia and Japan.

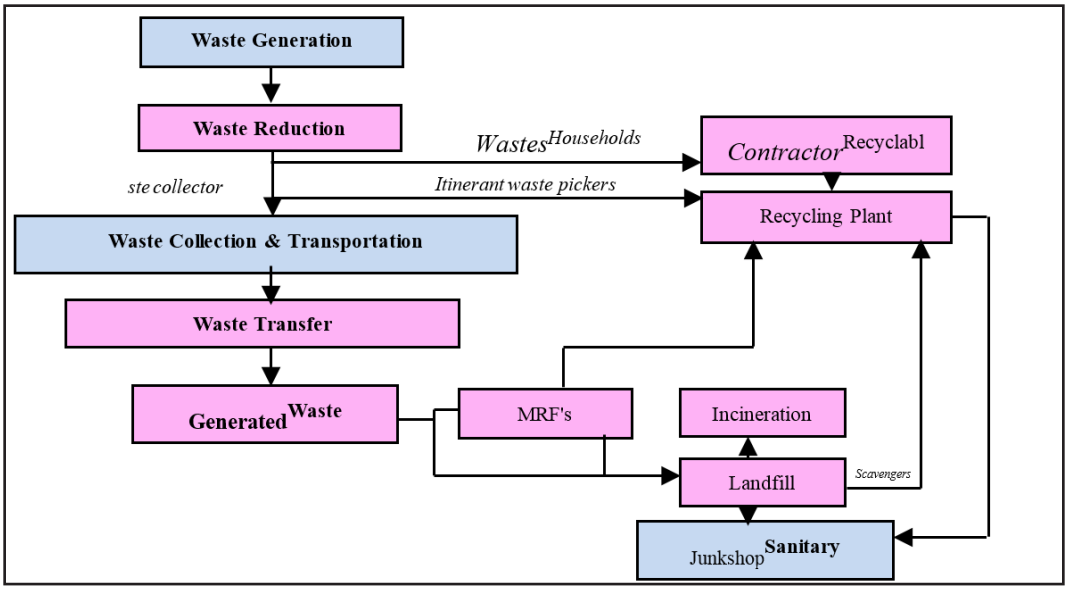

Figure 2: SWM System in Malaysia

Source: Author, 2012
Notes:
Solid Waste Management Process
Solid Waste Minimisation Process

Table 3: Projected Recycling Rate in Malaysia to 2020 (Source: Chong *et al.,* 2005)

Year	Waste generated (tons/year)	Recycling rate (%)
2001	160,600	3.0
2002	164,615	4.0
2003	168,730	5.0
2004	172,949	6.0
2005	177,272	7.0
2006	181,704	8.0
2007	186,247	9.0
2008	190,903	10.0
2009	195,676	11.0
2010	200,567	12.0
2011	205,582	13.0
2012	210,721	14.0
2013	215,989	15.0
2014	221,389	16.0
2015	226,924	17.0
2016	232,597	18.0
2017	238,412	19.0
2018	244,372	20.0
2019	250,481	21.0
2020	256,743	22.0

Table 4: Comparison between Japan and Malaysia in Solid Waste Management

Table 3: Projected Recycling Rate in Malaysia to 2020 (Source: Chong *et al.,* 2005)

Country	Main Legal Instrument	Institutional Arrangements	Strategic Planning Framework	Solid Waste Management Approach
Japan	• Waste Disposal and Public Cleansing Law; • Law for Promotion of Utilisation of Recycled Resources; • Law for recycling specific home equipment into new products; • Law for Establishing a Sound Material-Cycle Society Law; • Food Recycling Law; • End-of-Life Vehicle Recycling Law.	• Establishment of: • Bring out the knowledge and demonstrations on recycling; • Creation of collection system group in local communities; • Improve the efficiency on waste technology facilities; • Construct highly efficient facilities; • Subsidies of Urban 3R's Promotion Project Programme; • Focuses on product manufacturing and changing public attitude.	• The National government in Japan enforced solid waste law and regulations; • The local governments develop solid waste strategies in each elements of the solid waste management system; • The local governments develop and help to change the public attitude; • The government of each stages manage and monitor national solid-waste framework;	• The local governments transfer knowledge of solid waste minimisation to communities (waste separation, waste collection); • Develop a special and sophisticated recycling system with high technologies with focus on the effective utilisation and safe treatment of resources; • Conduct federal research on waste product use; • Reduce waste production, recycle, and purchase recycled materials; • Develop high-technology incineration and sanitary landfill facilities; • Monitor waste separation collected by the municipalities or group collectors and stored for collection by the recycling company.
Malaysian (Selangor)	• Action Plan (ABC) 1985; • Action Plan for a Beautiful & Clean Malaysia 1998; • National Vision Policy Plan 2001-2010; • National Strategic Plan for Solid Waste Management in Malaysia 2005; • 11th Malaysia Plan RMK 2016-2020.	• Establishment of: • Legislation at the National Level to handle recycling in the 1980s; • All local governments took over of the solid waste	• Establishment of: • Federal laws on solid waste management; • State government developed waste management laws in line with national laws; • Local governments implement the laws.	• Involvement of households in waste management through: - waste generation - waste reduction - waste storage - waste collection - waste transfer - waste disposal

Methodology

Shah Alam City is the capital of the city of Selangor Darul Ehsan, Malaysia. Shah Alam city is the fastest growing district in Selangor. It is also nearest to the city of Kuala Lumpur. The total population is 646 890 people, (2010) and further increased to 700 000 people in 2014 after several developments have taken place (MBSA, 2012).

The analysis of this study is based on primary data collected in Shah Alam City Hall, Selangor, Malaysia. The method adopted for achieving the first objective was through a survey of 100 households (low, medium and high housing cost) which participated in the household waste generation and composition analysis. These households were provided five (5) polythene bags by the researcher to separate their daily wastes for a period of fourteen (14) days. The researcher visits each household in the evening to collect the polythene bags. To encourage household participation, a token gift was given to them. In order to have a sample that represents the study area, the survey was carried out in the three residential neighbourhood (low, medium and high cost). In each of the neighbourhood, around 33 to 34 households were surveyed for a period of 14 days. Daily measurement of waste generated per household was recorded in a form throughout the period. This study used observation method to observe the various stages involved in SWM system. According to Yin (1982), observations are a form of data or evidence that do not depend solely on verbal behavior, and it is a method that allows researchers is look or observe the phenomenon under study directly. This method was used in order to achieve the second objective, namely: to examine the various stages that are involved in household SWM practices in Shah Alam City Hall, Selangor, before it gets to the recycling plant (services recycling systems). Field observations were also used to compare the actual waste management situation in the study area with the information gathered from analyses. Observations were made on current household use of SWM services in the study area. During this process, pictures were taken as evidence. The collected sample in the study area was analysed with the help of NVIvo software.

Solid Waste Management in Shah Alam, Selangor

Shah Alam is one of the major cities in the Klang Valley with atotal area of 293 square km (MBSA, 2012). SWM in Shah Alam City Hall was initially handled by MBSA. This was done through many departments in the LA. In October 16, 2011 the Selangor State Government directed all LAs in the state to take over the contract of SWM fully from the Alam Flora Sdn. Bhd. (MBSA, 2012). These contractors are monitored by a special team from MBSA. Figure 3 shows various stages involved in the SWM and minimisation system.

Waste Generated

Solid waste generated was 1.89 kg per household. According to the Town Planning Department (MBSA) 2012 report, the population of Shah Alam was estimated to be 866,832. In view of this, the estimated solid waste generated per person/per day would be 0.43 kg which translates to 372,737.76 kg daily for the entire Shah Alam city. The wastes are classified into three: (i) food waste, (ii) recyclables, (iii) non-recyclables. The results show that 45.51% (1,201.61 kg) of the wastes generated are recyclables materials, 33.98% (897.18kg) are food wastes and 20.51% (541.54 kg) are non-recyclables. For waste composition, results show that plastic (18.28%) constituted more among recyclable items followed by paper (11.95%), glass (4.67%), textile (3.91%), leather (2.23%), aluminums (2.15%), cooking oil (1.56%) and metal (0.76%). For non-recyclables, hazardous items constituted less than 0.51% while miscellaneous wastes accounted for about 20%. In this study, food waste constituted about 33.98% of the total waste generated per household. Figure 4 shows the SWM and minimisation system

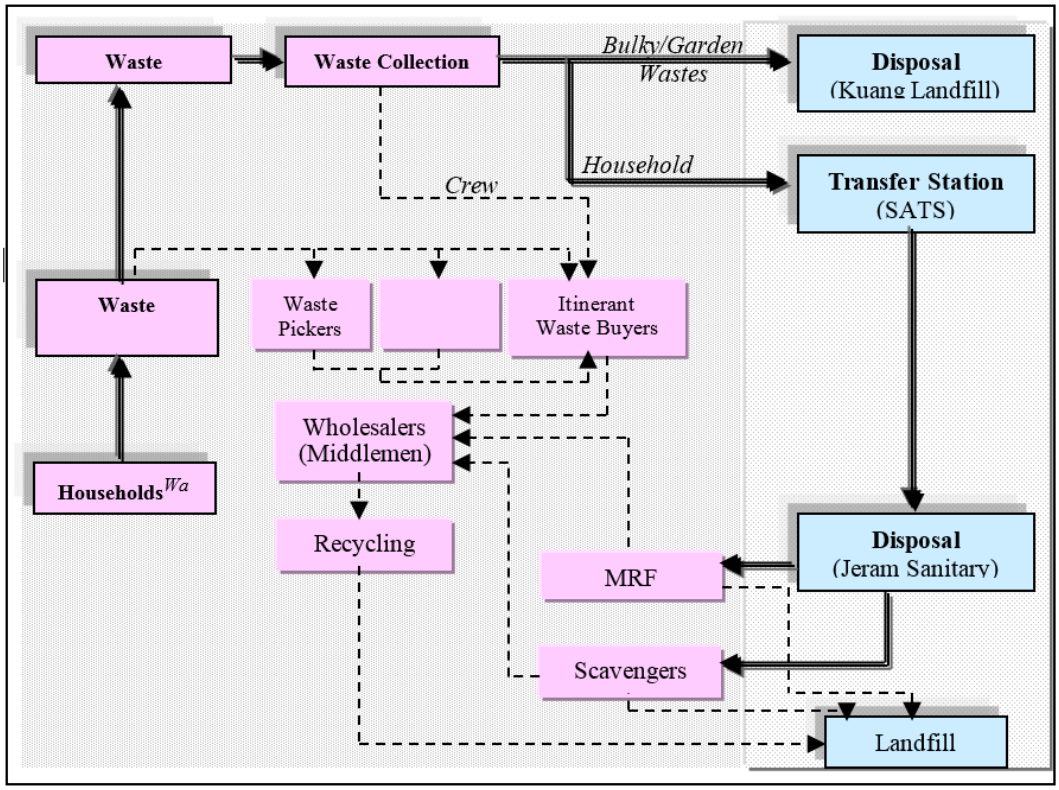

Figure 4: SWM and minimisation system

Source : Author, 2013

Note:
MRF (Materials Recovery Facility)
Bulky/Garden Waste (Furniture, tyres, oven, garden wastes and other)
(Domestic Waste (Ordinary day-to-day use)

Solid Waste Management Process *Solid Waste Minimization Process*

Waste Handling, Storage and Processing at source

Two types of storage facilities (primary and secondary) are available in the study area. The primary storage facility is located in front of each house while secondary storage is located at a central point within the apartments. Figure 5 shows the types of storage facilities.


Figure 5: Types of storage facilities

During the survey, it was observed that all households in the study area stored their wastes in polythene bags. According to the circular issued by the LA, waste bins are not only for recyclable items but should include all waste in order to ensure that the wastes do not litter the environment.

Waste Collection

Waste collectors are involved in house to house collection of wastes. Solid waste minimisation by households could help in the reduction of quantity of waste and the critical element of solid waste minimisation involves waste handling and separation at source. There are two modes of waste collection identified from the study. They are: (1) primary and (2) secondary waste collection. Primary waste collection consists of house to house collection by collection crews. This method is more prominent in the landed house and those areas with well-planned road networks that can easily accommodate vehicles that collect waste. On the other hand, secondary method is mainly used in the high-density area. It involves communal container where collector crews are expected to pick them up. Households are expected to carry their waste to the communal waste center which is later emptied by a collection truck. Findings from the study reveal that the combination of these two methods is a good practice, because the collection crews can work very well without interruption especially from the traffic. The crews also help in waste separation by removing any recyclable materials from the waste before throwing them into the compactor truck which carries the waste to the disposal site. The recyclable materials are placed in sacks on either side of the truck and when full will be tied. The frequency of primary collection is thrice a week. Each area has its specific days of waste collection (Monday, Wednesday and Friday or Tuesday, Thursday and Saturday). The secondary waste collection is done daily.

Waste Transfer and Transportation

Solid waste delivery system involves the movement of waste from transfer station to disposal site. The authorities have an agreement with private companies because they do not have waste collection facilities, especially vehicles. The transfer station is a temporary site for depositing waste before it is transported to the desired end point. One of the reasons for establishing waste transfer station facilities is the long distance between sources and disposal sites and it would be more cost-effective to transport the waste in a larger load vehicle or trailer more suited for the long journey to the final disposal site. Shah Alam Transfer Station (SATS) is designed to receive about 1,200 tons of solid waste daily. The station is expected to enhance its capacity so that it could receive

around 2,500 tons per day (WHB Environment, 2014).

Initially, when the trucks arrive, they have to weigh the capacity at weighbridge and queue before disposing the waste. The vehicles drive to the upper floor and tip directly into 'tipping platform' built over the silos (refer Figure 6 and Figure 7).

Figure 6: 'tipping platform'
(Source: WHB Environment, 2014)

Figure 7: Compactor truck
(Source: WHB Environment, 2014)

According to WHB Environment (2014), the solid waste will be compressed in a cylindrical silo where the water will be squeezed to reduce size, weight and stench. Each 100 tons of wastes could be compressed to about 20 tons. It also explains that, silo is a container enabling 100% water tight, which prevents leakage during loading and transportation and each prime mover truck will transfer 20 tons wastes directly to the landfill site. This is essentially a very clean operation with excellent control of most potential environmental effects.

One of the managers of WHB Environment stated that the reception of solid waste per day in SATS is 1,200 tons and one compactor truck loads 6 tons. This shows that in one day 200 compactor trucks are received. Subsequently, locator compactor will do the compression process from 100 tons to 20 tons, which is about 80% in order to reduce weight. The compression of waste by locator compactor leads to about 240 tons reduction in waste daily. Indirectly, this could lead to decrease in fuel consumption, pollution, traffic congestion and the amount of solid waste disposal to the sites.

Waste Disposal

Bukit Tagar Sanitary Landfill serves MBSA and the Klang Valley. Solid wastes from SATS are brought to Bukit Tagar Sanitary Landfill, Jeram, for disposal. The distance is about 60 km and takes around 45 minutes to 1 hour by road to Shah Alam. Bukit Tagar Sanitary Landfill has Materials Recovery Facility (MRF) which has served as source raw material for the recycling industry in Malaysia. Figures 8 and 9 show the Bukit Tagar sanitary landfill and MRF.

Figure 8: Bukit Tagar, Sanitary Landfill
(Source: www.panaroma, 2014)

Figure 9: Materials Recovery Facility
(Source: The Star Online, 2012)

This sanitary landfill and MRF is operated by Worldwide Landfills Sdn. Bhd. A Materials Recovery Facility (MRF) is where recyclable materials collected from households are sorted into different types (e.g. paper, plastics, cardboard, metal) using a mixture of manual and automated methods. After sorting out these materials, they are sent to manufacturers where they are used to produce new products.

Analysis

Solid wastes generated are classified into three groups: i) organic waste (33.98%), ii) recyclable materials (45.51%), and iii) non-recyclable materials (20.51%). Earlier studies by Saeed *et al.,* (2009) and Budhiata *et al.,* (2012) had reported 40% or more organic waste in Shah Alam City. In this study, organic waste constituted about 33.98% of the total waste generated per household. Thus, organic waste constituted less than 40% of the waste generated by households in the study area compared to more than 40% reported in earlier studies. The method adopted here used the source separation and recycling of waste, which revealed the highest amount of recyclable (45.51%) waste generated, and the second method used is composting, as it involves 33.98% of the total organic wastes. Therefore, waste generation and characterisation rates for household activities can be used to estimate the impact of new development on the local waste stream and will help in the design of an effective waste storage, collection, treatment, and management plan for the type of housing in the city. In this case, perhaps the local authority could plan some social or infrastructure legislation that would encourage households to practise waste separation and composting.

Two types of storage bins (primary and secondary) were found to be available in the study area. It was identified in this study that households were ignorant of at-source sorting techniques in the SWM practice. Shashidar and Vinodhkumar, (2011) noted that in countries that do not practice proper sorting techniques, the public are not encouraged to sort their wastes at source. Accordingly, the circular issued by the LA should cover all waste bins so that wastes are not sorted out by households before disposal. Waste bins are usually kept in front of the house waiting for collection. The crew members unload the wastes from the bins and put them in the collection trucks. The crew try to separate some of the waste before unloading them in the truck. This is done within very short period of time as they have to cover a certain neighbourhood based on their time schedule. Thus, findings from the study revealed that waste collection (frequency, method) reflects the best practices. However, the type of vehicles used are not up to date, as the collectors still use

old vehicles that do not have recycling facilities. In view of this, it is suggested that LA should propose waste collection using a separate truck or using alternate days for different types of wastes.

In SATS, as mentioned previously, the waste is transported to the final disposal site in larger load vehicle or trailer more suited for the long journey. In this case, the LA should create buy-back centres in the transfer station, making it easy for collection crews to sell the recyclable items. Again, it should be mandatory for all collection trucks to bring along all recyclable items to the transfer station where it will be sold under the supervision of LA officials for accountability.

Findings

The analysis found that the local authority focuses only on management of solid waste, while ignoring waste minimisation. In contrast, developed countries have been successful in waste minimisation because they are excellent in both waste management and waste minimisation, but Malaysia is still concentrating on managing solid waste only. Williams, (2005) noted that a successful country should have both good solid waste management and good waste minimisation because that is one of the key themes of sustainable development. Observations revealed that the study area does not have formal infrastructures for storage, collection, and disposal of recyclable materials. There are no proper storage bins provided for some households. In addition, there are no recycling bins for households to enable them to separate different waste types. Instead, all wastes are stacked together in the waste disposal bin at the front of each household. However, there is lack of separation of the waste generated in Shah Alam at present. People often tend to dispose of their waste by dumping all types of waste into the same waste bin. Hence, it would be difficult for the recycling companies or the city council to separate the wastes into their respective categories.

Thus, it is of great importance to increase public awareness on the importance of solid waste minimisation, to increase the participation rate of households in the study area. In order to improve the current waste collection system, strict policies regarding at-source separation of waste is needed from LA. The MBSA should have a strict monitoring network when it comes to at-source separation of the waste. Sorting wastes based upon their characteristics will help the recycling companies and the city council to separate the waste with ease. The sorted waste from different sectors can then be transferred to the waste collection truck by the city council. Unfortunately, the LA does not have a comprehensive plan for solid waste minimisation, but focuses only on SWM. While developed countries have been successful in waste minimisation, Malaysia is still only managing rather than minimising solid waste. This means the nation is still at the beginning stage of waste minimisation (3R's, recycling bins, recycling centres, and recycling program). There are various Non-Government Organisations (NGOs) and Community Based Organisations (CBOs) working in urban development planning, and their roles and responsibilities should be clearly defined before the planning starts. This will help in overcoming some of the challenges in SWM and minimisation in the country.

Conclusion

The findings presented in this paper represent the current waste management practices in Malaysia and Shah Alam city. From the results and analysis, it is clear that the flaws in the current waste management practices are due to a lack of public awareness, inadequate waste management plans, lack of a proper recycling infrastructure, and managerial inefficiency from LA. The current waste minimisation system in Shah Alam is ineffective. The contribution of the study is the use of a scientific quantitative approach to estimate the volume of waste generated to improve levels of solid waste minimisation and the feasibility of improving

these levels. This study has been able to present an estimate of the quantity and the composition of the solid waste generated per household in the study area and by level of solid waste minimisation households. In addition, it reveals details about the SWM system within the residential neighbourhoods. Findings from this study have led to the proposal of a Housing Solid Waste Management System (see Figure 4). The local authorities should give serious attention to solid waste minimisation. The first stage should involve waste reduction by households, the second stage should involve treatment (plant recycling, composting and incineration), and the last stage should be MRF. Therefore, it is suggested that the current management system should introduce at-source separation techniques as part of waste management practices.

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References

Agarwal, A., Singhmar, A., Kulshrestha, M., Mittal, K. (2005). Municipal solid waste recycling and associated markets in Delhi, India. *Journal of Resources, Conservation and Recycling.* 44:73– 90.

Amber Regency Travel Sdn. Bhd. (2012). *Malaysia Plan.* Retrieved from www.ambertravel.com.my

Budhiarta, I., Chamhuri, S., Hassan, B. (2012). Current Status of Municipal Solid Waste Generation in Malaysia. *International Journal of Advanced Science Engineering Information Technology.* 2:16-21.

Chua, K.H., Mat Sahid, E.J., Leong, Y.P. (2011). Sustainable municipal solid waste management and GHG Abatement in Malaysia. *Journal of Green and Energy Management.* 1:26-28.

Chong, T.L., Matsufuji, Y., Nasir, H. (2005). Implementation of the Semi-aerobic landfill system (Fukuoka Method) in Developing Countries: A Malaysia Cost Analysis. *Journal of Waste Management.* 25:702-711.

DSM (Department of Statistics Malaysia). (2000). *Population and Housing Census of Malaysia 2000: Population Distribution and Basic Demographic Characteristics*. Department of Statistics Malaysia.

DSM (Department of Statistics Malaysia). (2010). *Population and Housing Census of Malaysia 2010: Preliminary Count Report.* Department of Statistics Malaysia.

Eusuf, M.A., Ibrahim, M., Mohd Din, S.A., Islam, R. (2007). Solid Waste Generation Characteristics: The Malaysian Local Authorities Outlook. *Journal of the Malaysian Institute of Planners.* 2011, IX:51 – 76.

EASUR (Urban Development Sector Unit East Asia and Pacific Region)-World Bank. (1999). *What a Waste: Solid Waste Management in Asia and Pacific Region.* World Bank.

EPU (Economic Planning Unit). (2006). *Ninth Malaysia Plan/Rancangan Malaysia Ke-9 (RMK9) (2005–2010);* Percetakan Nasional Malaysia Berhad.

Franchetti. (2009). A Systems Approach Solid Waste. Analysis & Minimization, McGraw-Hill Companies, Inc.

Goh, B.L. (2007). Malaysia, in Solid waste Management: Issues and Challenges in Asia. *Environmental Management Centre,*

Mumbai, India: Asian Productivity Organization.

Hassan, M.N., Chong, T.L., Rahman, M., Salleh, M.N., Zakaria, Z., Awang, M. (2001). Solid Waste Management in Southeast Asian Countries with Special Attention to Malaysia. *Proceedings on Eighth International Waste Management and Landfill Symposium*. Cagliari, Italy. 14:56-71.

Hoornweg, D., Lam, D., Chaudhry, M. (2005). *Waste Management in China: Issues and Recommendations*. East Asia Infrastructure Development. The World Bank, Washington, DC, USA.

JICA (Japan International Cooperation Agency). (2006). *The Study on National Waste Minimisation in Malaysia.* Global Environment Department. JICA.

Kathirvale, S., Muhd Yunus, M.N., Sopian, K., Samsuddin, A.H. (2003). Energy Potential from Solid Waste in Malaysia. *Journal of Renewable Energy.* 29:59-567.

Majlis Bandaraya Shah Alam. (2011). *Pengambilan Aliran Kerja-Kerja Pembersihan Awam dan Kutipan Sisa Pepejal oleh 12 PBT Selangor.* Bulletin Isu 2011 dan 2012. MBSA.

Majlis Bandaraya Shah Alam (2012). *Laporan Tahunan 2012*. MBSA.

Mary Maguire. (2010). *Stench From The Dump.* Retrieved from www.panaroma.com.

MHLG (Ministry of Housing and Local Government, Malaysia). (2005). National Strategic Plan for Solid Waste Management. Kuala Lumpur.

MHLG (Ministry of Housing and Local Government, Malaysia). (2010), *Strategic Solid Waste Management: The Malaysian Approach.* Sunway Hotel Resort and Spa, Kuala Lumpur.

Ministry of the Environment, Japan. (2012). *Recycling Policy,* Retrieved on June 02, 2013, from http://www.meti.go.

Nadzri, Y. (2012). Solid Waste Management in Malaysia: The Way Forward. *Ministry of Housing and Local Government, Malaysia.*

Nazeri, S. (2002). *Element of Solid Waste Management.* Retrieved from www.slideserve.com.

Nickolas, J. T. and Charles, M. (2014). Energy and Economic Value of Municipal Solid Waste (MSW), Including Non-Recycled Plastics (NRP), Currently Landfilled in the Fifty States, Columbia University, Retrieved on May 09, 2015, from http://www.americanchemistry.com.

Saeed, M.O., Hassan, M.N., Mujeebu, M.A. (2009). Assessment of Municipal Solid Waste Generation and Recyclable Materials. *Journal of Waste Management.* 29:2209–2213.

Schall, J. (1992). Does the Solid Waste Management Hierarchy, Make Sense? A Technical, Economic and Environmental Justification for the Priority of Source Reduction and Recycling, Solid Waste Management Project Working Paper, School of Forestry and Environmental Studies.

Shashidar, S., Vinodhkumar, V. (2011), *Waste Management in Botswana,* Master Thesis, Linköping University.

Takaoka, M., Nobuo, T., Naruo, Y. and Takahiro, M. (2011). Current Status of Waste to Power Generation in Japan and Resulting Reduction of Carbon Dioxide Emissions, *Journal of Material Cycles and Waste Management,* 3, 198-205.

The Star Online. (2012). *Milestone for recycling.* Retrieved from http://www.thestar.com.my/news/community/2012/11/17/milestone-for-recycling/.

Wahid, A.G., Hassan, M.N. (1996). Muda, Domestic and Commercial waste: Present and Future Trends. *CAP-SAM National Conference on the State of Malaysian Environment, Penang:* RECDAM.

W, A., Kadir, W.R. (2001). A comparative analysis of Malaysian and the UK waste policy and institutional framework. *Waste Management conference.*

Williams, P.T. (2005). *Waste Treatment and Disposal.* John Wiley and Sons ltd., West Sussex.

Worlatlas. (2012). *Explore The World.* Retrieved from www.worldatlas.com

Worldwide Holdings. (2014). *Worldwide Environment.* Retrieved from www.whbenvironment.com

Worrell & Vesiland. (2012), Solid Waste Engineering, Second Edition, Nelson Education, Ltd.

Yatim, S.R.M., Arshad, M.A. (2010). Household Solid Waste Characteristics and Management in Low Cost Apartment in Petaling Jaya, Selangor. *Journal of Health and the Environment.* 1:53-58.

Yin, R.K. (1982). *Design Issues In Qualitative Research: The Case of Knowledge Utilization Studies,* Abt Associates, Inc., Washington, Dc.

Zainal, Z.A., Rifau, A., Quadir, G.A., Saetharamu, K.N. (2002). Experimental Investigation of a Downdraft Biomass Gasifier. *Journal of Biomass Bioenergy.* 23:283-289.