1.0 INTRODUCTION

Waste has been a perennial source of pollution ever since the industrial activities generated enormous quantum of complex by-products. Proper waste management is very crucial to prevent further destruction to the ecosystem. It requires appropriate management facilities together with necessary laws and regulations. However the lack of awareness, facilities, technologies and most of all, sufficient funding made it unworkable (Zotos *et al*., 2009; Fauziah *et al*., 2004). These factors constrain Malaysia as a fast developing country in the Asian region to establish an effective waste management system (Chowdhury, 2009). Consecutive sections discuss current waste management practise in Malaysia and the need for its improvement.

1.1 Waste Management in Malaysia

Malaysia with a total land area of 328 550 km^2 produced approximately 30,000 tonnes/day of waste in 2009 (or 1.3 kg/capita/day) up from 18,000 tonnes in 2004 (Agamuthu *et* al., 2009; Agamuthu *et al*., 2004). In Malaysia, municipal solid waste (MSW) consists of domestic and industrial refuse, slightly differs to that of United State where MSW is garbage or trash in USEPA classification. Daily MSW volume in Kuala Lumpur was 99 tonnes in 1970s, but had increased rapidly to 587 tonnes in 1990s while to date it has exceeded 3200 tonnes (Latifah *et al*., 2009; Agamuthu *et al*., 2009). Similar increases are experienced by other states that it caused alarming situation particularly on the treatment and disposal options (Chong, 2003; News Strait Times, 2006). It was due to

the fast development in residential and industrial sectors, as well as, the mushrooming of urban areas. Currently, waste reduction and waste separation in Malaysia occurs at a very low rate with recycling at only 3% to 5% (Mohamed Osman *et al*., 2009; Chenayah *et al*., 2007; Agamuthu *et al*., 2004). Landfills are the largest repository of both municipal and industrial wastes in the country. Although landfilling of municipal solid waste is not a well-liked alternative, it is nonetheless an indispensable way of disposing waste cost-effectively (Roy, 1997). The lack of alternative routes in waste management resulting with 95% of the total waste generated in the country being disposed into the landfills (Fauziah and Agamuthu, 2009). Urban areas in Malaysia generate higher waste volume as compared to the sub-urban and the rural areas (Figure 1.1).

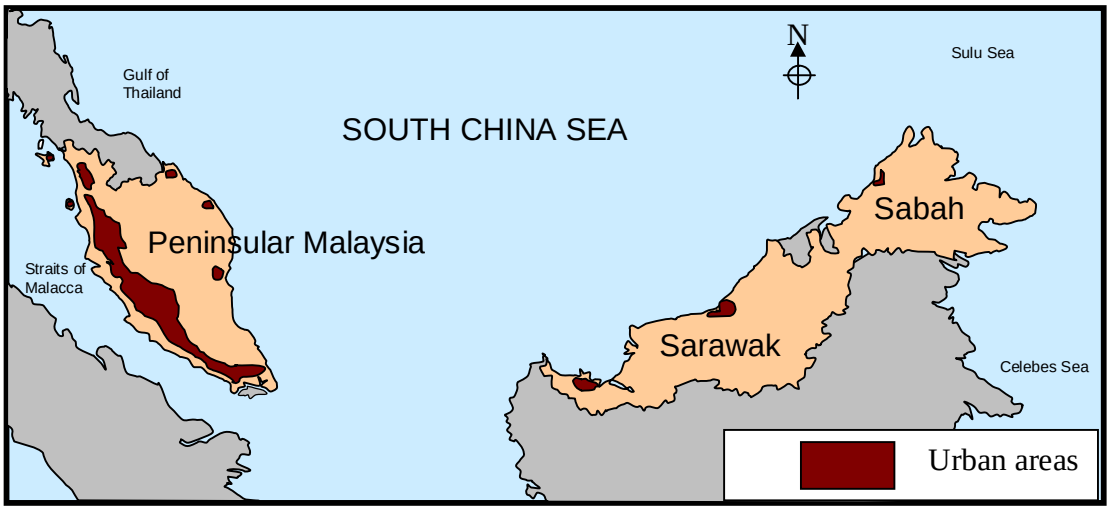

Figure 1.1: Urban areas in Malaysia (Adapted from Department of Statistics of Malaysia, 2000)

Total disposal site throughout the country is 301 including 41 closed facilities. The existing and actively operating 260 landfills are running out of space due to increasing

disposal of waste that premature closure is very apt to come to pass. The 3.6% annual increase in solid waste generation required appropriate facilities and technologies which are unfortunately not available to match the requirement for proper waste management (Tan, 2007; Fauziah and Agamuthu, 2003; Agamuthu, 2001). Sanitary landfills are only 3% of the total existing disposal sites in the country while the remaining are non-sanitary landfills. This makes the management of waste in Malaysia a more delicate matter to tackle.

Approximately 97% of landfills operate as mere open-dumps that lack proper lining system and without leachate treatment facilities. Previous studies have reported cases where the vicinities bordering landfill sites became highly polluted due to certain harmful gases generated from wastes filled surface and hazardous chemical (Moy *et al*., 2008). Contamination of the Selangor's water catchments on February 2006 had caused 16 landfills located adjacent to rivers to be closed immediately (News Straits Times, 2006). Improper disposal of MSW not only pollutes the environment but leads to the spreading of waste-borne diseases including cholera and the accumulation of carcinogenic compounds (Irigaray *et al*., 2007; Sharholy *et al*., 2008). Other contaminations reported include surface and deep soil contamination, water pollution and air pollutions.

Topics related to municipal waste generation and lack of waste segregation and recycling efforts need to be carefully studied to find a better and more practical system to manage Malaysian MSW. The difficulty in managing landfills in Malaysia is due to the lack of professional guidance and expertise, lack of proper capacity planning, unprofessional

collection plans, loose enforcement control, lack of awareness, indiscriminate dumping by residents for their own convenience, and the negative attitude among the public (Fauziah and Agamuthu, 2006). Due to the high moisture content (~70%) of Malaysian MSW, energy recovery is found to be very costly and difficult. The establishment of incineration plant to reduce waste disposal to landfills faces setbacks in term of energy inefficiency as well as strong objection from the public.

The local authorities have been spending significantly more than half of the income to manage MSW (Jamaluddin, 1998). Approximately more than RM 1 billion are allocated for waste management budget annually (Agamuthu and Fauziah, 2007). With privatization, the situation in Malaysia concerning municipal solid waste management seems to be improving, where activities involving waste collection and disposal have gained some professionalism allowing the improvement of topical sanitation and hygiene. The privatization had encouraged competition, which resulted with the upgrade services and productivity of waste management systems (Kamariah, 1998). Privatization may be a step towards achieving better service standards to the public, but a system to safeguard environment is more important and necessary. The passing of the Solid Waste and Public Cleansing Act 2007 and The Solid Waste and Public Cleansing Corporation Act 2007 after 10 years of debates in the Parliament promise major improvement in various aspects of waste management. Nevertheless, it is yet to be implemented that environmental degradation still continues and solution to rectify the problems remains unidentified. Table 1.1 indicates the generation of MSW in the year 2003 to 2008 by states in Malaysia.

Table 1.1: Malaysia MSW generation by states.

	Solid waste generated (tonnes/ day)					
	2003[1]	**2004**[1]	**2005**[2]	**2006**[2]	**2007**[2]	**2008**[2]
Johor	2199	2310	2391	2475	2561	2651
Kedah	1520	1597	1653	1711	1771	1833
Kelantan	1188	1248	1292	1337	1384	1432
Melaka	590	620	642	664	687	711
Negeri Sembilan	869	913	945	978	1012	1047
Pahang	1099	1154	1194	1236	1279	1324
Perak	1753	1842	1906	1973	2042	2113
Perlis	224	235	243	252	261	270
Pulau Pinang	1248	1312	1358	1405	1455	1506
Selangor	3245	3410	3529	3653	3781	3913
Terengganu	1013	1064	1101	1140	1180	1221
Kuala Lumpur	2893	3040	3146	3257	3371	3489
WP Labuan	72	75	78	80	83	86
Sabah	2641	2802	2900	3002	3107	3216
Sarawak	1982	2063	2135	2210	2287	2367
Total	**22 544**	**23 691**	**24514**	**25372**	**26260**	**27179**

Note [1] Source: Ministry of Housing and Local Government, 2003.

[2] Figures calculated based on 3.5% annual increase from MHLG (2003).

The largest percentage of MSW in Malaysia is contributed by Selangor with a generation of 3,923 tonnes daily. With most states experiencing rapid development, similar trend which is experienced by Selangor will also take place in other states. Therefore, this study focused on the MSW management of Selangor in order to generate suitable information, as well as, predicting future trends for the states in Malaysia. Following sections review the waste management in Selangor.

1.2 Waste Management in Selangor

Selangor has a population of approximately 5 million in 2009. Rapid urbanization resulted with positive economic growth, which indirectly caused the expansion of the population and rapid increase in waste generation (Figure 1.2).

Figure 1.2: Selangor state is located at the west coast of Peninsular Malaysia.

The waste management system in Selangor state is basically under the responsibility of three main stakeholders namely, Alam Flora Pvt Ltd. (AFSB), Hulu Selangor District Council (HSDC) and Kajang Town Council (KjTW). AFSB covers the areas of Kuala Selangor, Rawang, Sepang, dan Banting while HSDC and KjTC are responsible for the district of Hulu Selangor and the township of Kajang, respectively. Figure 1.3 indicates the location of the major landfills in the state of Selangor.

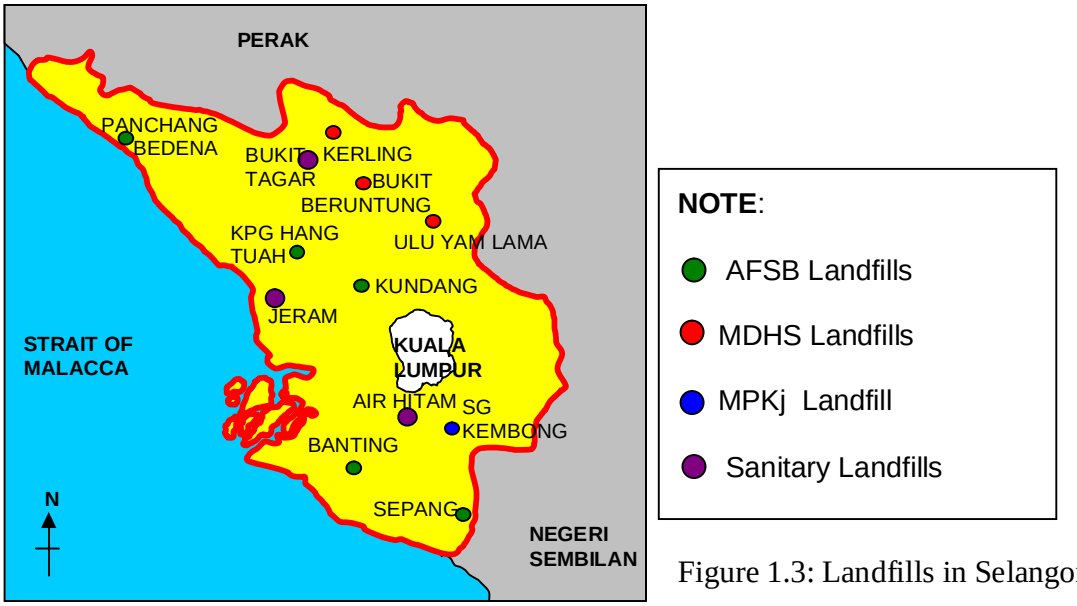

Figure 1.3: Landfills in Selangor.

1.2.1 Alam Flora (P) Ltd.

Alam Flora (P) Ltd or Alam Flora Sdn. Bhd (AFSB) is the consortium appointed by the Ministry of Housing and Local Government (MHLG) to provide waste management services in the central region of Peninsular Malaysia. It serves 6.1 million people over a total area of 72 388 km^2 in the central and eastern regions of Malaysia covering state of Selangor, Pahang, Terengganu, Kelantan, and cities of Kuala Lumpur and Putrajaya. The consortium currently is handling approximately 7100 tonnes of waste everyday. Its vision is to be a leading environmental management company to improve the quality of life (Mohamed Siraj, 2000). The establishment of AFSB started with the taking over on an interim basis from local authorities within the concession area. The servicing areas in Selangor under the jurisdiction of AFSB are indicated in Table 1.2.

Table 1.2: Servicing areas according to disposal sites under the jurisdiction of AFSB.

Landfill/ Disposal site	Service Areas
Kundang landfill	Batu Arang, Kundang, Rawang, Selayang, Kundang, Kuang, Sungai Bakau,Kepong, Gombak and Batu Caves.
Kampung Hang Tuah landfill	Sungai Buluh, Jeram, Batang Berjuntai, Tanjung Karang and Kuala Selangor
Panchang Bedena landfill	Sekinchan, Panchang Bedena, Sungai Nibong, Kampung Nelayan, Pekan Sabak, and Sungai Besar
Sungai Sedu landfill	Teluk Panglima Garang, and Banting
Ampar Tenang landfill	Sepang, Nilai, and the surrounding areas

1.2.2 Hulu Selangor District Council (HSDC)

HSDC, which is formerly known as Rawang Townhsip Board, is one of the local municipality given the jurisdiction under the Local Government Act 1976 (Act 171) to provide waste management service to local people in Hulu Selangor district. HSDC was established in 1975 with the responsibility to govern and develop the area under its jurisdiction covering approximately 91,296 acres. Numerous changes since then had been implemented to bring comfort and provide better facilities to the society. The objectives of the municipality are to establish a high quality living environment, to provide infrastructure in ensuring the progress in economy and development, to maintain the cleanliness and to improve the prosperity in all aspects of the areas.

Under the city service section, the municipality plays the role in collecting and disposing the municipal solid waste generated by the occupants in their area, cleaning roads from debris and solid waste in the town area, cutting grass, cleaning and clearing materials from clogging the public drains and regulating landfills and disposal sites under the responsibility of the municipality. Areas covered under the jurisdiction of HSDC include Bandar Baru Bukit Beruntung, Bandar Baru Bukit Sentosa, Serendah, Sungai Choh, Hulu Yam Lama, Hulu Yam Bharu, Batang Kali, Rasa, Kuala Kubu Bharu, Kerling, Kalumpang, Hulu Bernam, Bukit Fraser, Genting Highlands, Bandar Baru Sungai Buaya, Lembah Beringin and Bernam Jaya. In 2002, HSDC manages three landfills to dispose wastes generated by the areas under their jurisdiction. To date, only two is still operating. Table 1.3 indicates the areas and the landfill involved.

Table 1.3: Areas covered by related landfills under the jurisdiction of Hulu Selangor District Council.

Landfill	Areas covered
Bukit Beruntung landfill	Bandar Baru Bukit Beruntung, Baru Bukit Sentosa, Serendah, Sungai Choh
Hulu Yam Bharu landfill	Hulu Yam Lama, Hulu Yam Bharu, Batang Kali, Rasa, Kuala Kubu Bharu, Kerling, Kalumpang, Hulu Bernam, Bukit Fraser, Genting Highlands,
Kerling landfill	Bandar Baru Sungai Buaya, Lembah Beringin, Bernam Jaya

Generally, the waste management system implemented by the municipality was able to manage disposal of MSW from the area rather efficiently. This was accomplished with the appointment of sub-contractors to undertake the responsibility to collect and transfer waste from designated areas. The sub-contractors are responsible in ensuring smooth MSW collection and transfer to the nearest landfill managed by HSDC.

1.2.3 Kajang Town Council (KjTC)

KjTC serviced the district of Kajang which is located approximately 20 km to the south-east of Kuala Lumpur. The area generally constructed of hilly landscape with valleys formed near the rivers including Sungai Langat, Sungai Bangi, Sungai Semenyih and Sungai Chua. Kajang has a population of 189,400 people with major activities include commercial, education and agricultural. The objectives of the municipality are to establish a high quality living environment, to provide infrastructure in ensuring the progress in economy and development, to maintain the cleanliness and to improve the prosperity in all aspects of the areas. Also, the establishment of the municipality is to provide efficient and quality municipality services related to solid waste management and area cleaning.

The areas covered under the jurisdiction of KjTC include Bandar Baru Bangi, Bandar Bangi, Kajang, and many more. All of the MSW collected by the waste collectors from these areas are disposed into Sungai Kembong landfill. The management of the landfill includes the monitoring and leveling of waste by KjTC. The landfill is an open-dump that lacks any lining system and leachate collection pond.

1.3 Problem Statement

Current waste management practice in the country is below the satisfactory level of a developing nation. Among the obstacles to overcome are the absent of updated and consistent data on waste management, improper management of disposal sites, uncontrolled pollution from disposal sites, lack of participation from the public, non-sustainable waste management in terms of cost, and the pressures to safeguard the environment. In addition to these factors, Malaysians are predicted to generate larger volume of waste in near future. Therefore, prompt action should be taken to find a solution to ensure a proper waste management system is in place. This would require sufficient and updated information to plan appropriate improvement to guarantee the proposed action is feasible for the country. Selection of Selangor for the study is appropriate where the results are expected to be the representative to all state in Malaysia in the near future. Within five years, the state indicated 27% increase in MSW generation from 3,090 tonnes in 2002 to 3,983 tonnes in 2008. This is contributed by the high consumption and the lack of appropriate waste minimization program by the local government. Selangor's generation of MSW is projected to exceed 5000 tonnes in 2017 (Ministry of Housing and Local Government, 2003). This study is very crucial to identify a suitable system that would benefits economically and socially, as well as, preserving the environment. The possibilities of alternatives routes from total landfill disposal are also looked into. The outcomes of the studies is hoped to enable the postulation of an appropriate and successful waste management system applicable to all states in the country. Also, a solution is needed to improve participation through changes in ethics and level of awareness among the public.

1.4 Objectives of Project

The objectives of this research are to gather vital information on disposal sites in Selangor, their effect on socio-economic aspects of the people and the environment, including soil contamination, water pollution impacts, and others. Also the study is aimed to determine the possibilities of source recovery, recyclability, and compostibility of the municipal wastes generated in the state, as well as, to identify the level of awareness and the level of public participation pertaining to MSW. The final outcome of the study is to plan and program future waste management strategies, which will best suit Selangor state. The study entails the following:

A Waste characterization and Quantification

i) To characterize and determine the percentage of waste received by the nine non-sanitary landfills in Selangor.

ii) To conduct detailed composition studies at three-selected site that represent urban, sub-urban and rural type of disposal sites.

iii) To characterize and analyse the physical and chemical components of solid waste generated by households, institutions, commercial and industries.

B Landfill detailed study (Urban disposal site).

i) To determine the characteristics of leachate.

ii) To determine the calorific value of waste samples.

iii) To carry out studies on leachate treatment with physical, chemical and biological options.

iv) To conduct methane oxidation study.

C Composting studies - to carry out vermicomposting study of organic waste with various combinations.

D Socio-economics of waste management in Selangor

i) To determine the socio-economic status, its relationship with waste characteristics and quantity. The survey on socio-economic status will be made to compare waste generation types and quantity to the living standards of people, educational background and other factors.

ii) To determine the level of environmental awareness among the public.

iii) To determine the possibility and viability of Reduce, Reuse, and Recycle (3Rs) options implementation and the response expected from the public.

E Model development of waste management system using SWPlan, a solid waste management planning software.

i) To evaluate the current waste management system for rural, sub-urban and urban area in Selangor,

ii) To determine the overall waste management system in Selangor (average)

iii) To simulate future model based on the Malaysian waste management target set for 2020.