CHAPTER 1

INTRODUCTION

1.1 Solid Waste and Landfills Management in General

Management of solid waste in a proper way is one of the main challenges in every country. The aggregate of citizens' activities have a potential to produce a massive volume of solid waste (Zerbock, 2003). Statistic by World Bank Group (1999) indicated that the Asian urbanites produced approximately 760,000 tonnes of municipal solid waste (MSW) daily, or 2.7 million m^3 per day. By 2025, the daily amount of MSW produced is forecasted to achieve about 1.8 million tones (5.2 million m^3 per day). These numbers are estimated based on moderate rates that the real values maybe doubled.

Research by Visvanathan and Glawe (2006) indicates the differences of waste composition among some Asian regions and western developed countries (Table 1.1). It is because that various regions have different characters of waste generation, the waste management system should be built based on local circumstance and economic status.

Table 1.1 Waste Compositions of Various Countries (Percentage by Weight)

Country	Paper	Textile	Plastic	Metal	Glass	Wood	Ash/dust	Organic
China	6.9	4.7	7.3	0.5	1.6	6.9	19.2	52.6
India	7.6	4.7	3.8	1.7	2.1	NA	40.1	39.6
Malaysia	15.0	3.0	14.0	4.0	3.0	4.0	10.0	47.0
Sri Lanka	12.3	NA	6.8	3.7	3.0	10.2	NA	64.7
Thailand	7.7	2.7	13.7	3.1	4.3	3.6	5.0	56.2
Europe (average)	32.0	4.0	7.0	8.0	10.0	NA	9.0	30.0
America (California)	41.0	2.4	10.7	7.9	5.8	5.0	0.5	24.1

Note: NA = not available

(Source: Visvanathan and Glawe, 2006)

Asia occupies much of the urban growth in the developing world, and Asian populace has more cities than any other part of the world (APO, 2007). The effects of the increasing population in Asia include the rapid urbanization and economic development, which already have given much stressful load on MSW management (APO, 2007).

Based on these situations, the importance of an efficient and effective solid waste management system (SWMS) becomes more crucial. In the following five years, the number of people living in cities will be doubled than that in 1987, and nearly 90% of this growth will take place in the developing world (APO, 2007). This will result with these cities producing more waste, while the composition of waste will become more diversified (APO, 2007; Shekdar, 2009; The World Bank, 1999). The generation rates in the main Asian countries based on the GDP ranking are listed in Table 1.2.

Table 1.2 Information on GDP and Waste Quantity for Some Asian Regions

Region	GDP (PPP) per capita estimated for 2007 (USD)	Waste generation (kg/capita/day)
Hong Kong	37,385	2.25
Japan	33,010	1.1
Singapore	31,165	1.1
Taiwan	31,040	0.667
Sourth Korea	23,331	1.0
Malaysia	12,702	0.5-0.8
Thailand	9,526	1.1
China	8,854	0.8
Philippines	5,409	0.3-0.7
Indonesia	5,096	0.8-1
Sri Lanka	5,047	0.2-0.9
India	3,794	0.3-0.6
Vietnam	3,502	0.55
Lao PDR	2,260	0.7
Nepal	1,760	0.2-0.5

(Source: Shekdar, 2009)

The governments from Asian countries have invested at least US $25 billion per year to solve these issues mentioned about urban MSW management (The World Bank, 1999). It is estimated conservatively that Asian countries may spend double figure for solid waste management activities in 2025 (The World Bank, 1999).

Pugh (1999) reported that the general way of disposing MSW in Asian developing countries is via open dumping. Unfortunately, the dumping sites of states have similar

short comings –unorderly located, uncovered wastes in the dumping sites, uncontrolled burning, tons of untreated polluted water (leachate), insects and rat infestations, and waste scavenger picking up any valuables from waste without organized management.

In developing countries, waste management in most cities is inefficient. This is because the large population does not receive a proper waste collection and treatment system. From the environmental and economical aspects, since only partially of generated waste is collected, transportation, recycling and/or disposal of solid waste are inadequately operated (Schubeler, 1996). The common problems include lack of cover layers and compaction, lack of leachate treatment, impropersite design, and uncontrolled pickers at the landfill site. Therefore, the poorly managed dump-sites and landfills have been creating significant risks to environment and human health (Visvanathan *et al.*, 2003). Thus, there is an urgent need in managing MSW system efficiently. The 'western way' from developed countries was chosen in some situations. However, in most Asian developing countries, these kind of western approaches were totally inefficient because of the different characters of solid waste and high expenses of maintaining facilities (Bodelius *et al.,* 2000). Therefore, in these Asia regions, it demands economic evaluation and research on landfill management to improve the efficiency and sustainability of landfill while protecting the local environment.

1.2 Solid Waste and Landfills Management in Malaysia

From 2003 to 2010, the Malaysian population increased from about 24.7 million to approximately 28.3 million. During the 10 years period from 2000 to 2010, the average GDP Growth of Malaysia was 1.17% and the GDP of Malaysia reached to US $237.804 billion putting Malaysia as a rapidly developing economy in Asian region (The World Bank, 2011). With this rapid increase of population and economic development, the MSW management system needs to meet these challenges as well. According to Malaysia Environmental Quality Report in 2010, over 30,000 tonnes of waste was produced each day in Malaysia. Along with the gradual population and urbanization development, the quantity of waste generation keeps on growing, and it was recorded that just less than 5% of these generated solid waste were recycled. Table 1.3 indicates the trend of MSW generation between 1996 and 2000 in major Malaysian cities.

Table 1.3 Solid Waste Generations in Peninsular Malaysia by States (Metric Tonnes)

States	1996	1997	1998	1999	2000	Average growth rate (1998-2000)%
Kuala Lumpur	NA	NA	1,058	1,070	1,082	1.14
Selangor	NA	NA	1,169	1,204	1,240	3.04
Pahang	NA	NA	202	206	210	1.98
Kelantan	NA	NA	123	126	120	-1.22
Terengganu	NA	NA	119	122	125	2.52
Negeri Sembilan	246	250	267	278	291	4.69
Melaka	192	200	208	216	225	4.30
Johor	854	890	927	956	1,005	4.49
Perlis	26	27	28	28	29	1.79
Kedah	507	538	569	569	631	5.49
Pulau Pinang	570	591	611	611	648	3.03
Perak	672	696	719	719	763	3.06
Total	3,066	3,192	6,000	6,137	6,378	2.86

Note: NA = not available

(Source: Zamali *et al.*, 2009)

According to Hassan *et al.* (1997), many environmental and health problems is due to the fact that the amount of MSW generated in the country, which is raising geometrically particularly in some large cities such as Kuala Lumpur (KL) and it is even more disastrous with the improper and unsustainable solid waste management system.

Water and air pollution, and solid waste are considered as three main environment problems in Malaysia. As one of the significant environmental problems, solid waste management plays a crucial role to sustain life within natural capacity in the future. Improper management of solid waste causes many negative impacts. These effects include frowzy areas surrounding garbage bins and landfill areas, unsystematic MSW collection, and indiscriminate waste dumping sites. Another outstanding issue is on the privatization of solid waste collection and management (Hassan, 2000).

APO (2007) reported that MSW management is a primary problem in Malaysia which can be clearly identified by roadside littering, clogged drains by trash and filled rivers coverage with grimy garbage. Therefore, the regulations and standards of solid waste management in Malaysia have quite a big space to be improved: outmoded of solid waste generation rates and the composition of solid waste, low-efficient storage and collection systems, non-separated disposal of solid waste (like mixing the normal garbage with toxic and hazardous waste), as well as improper waste dumping sites. Besides that, the Malaysian public awareness and knowledge about environment pollution still need to be improved, like solid waste management issues and pollutions caused by improper waste dumping. APO (2007) also mentions that among almost 1800 rivers in Malaysia, more than half have been polluted, and one of the major reasons is improper SWM. Furthermore, low-efficient SWM can also contribute to the climate change due to the released of Greenhouse gases.

Landfilling activity normally involves burying of waste. It is a common practice in most countries. If a proposed landfill near a city can be appropriately designed with an

efficient management system, it can contribute towards good hygienic and relevant excellent solid waste disposal option. Furthermore, a main byproduct of landfills – namely landfill gas (methane and carbon dioxide) is produced as organic waste breaks down anaerobically. Though the landfill gases are greenhouse gases, it has the potential used as energy generation source.

Economic and urbanisation prosperity are always followed by the greater the amount of solid waste generation (Hassan, 2000). According to Tchobanoglous *et al.* (1993), there are mainly six functional components in solid waste management. These include the waste generation, waste storage and processing, the solid waste collection, delivery and transportation, waste to treatment, recycling and recovery procedures, and finally disposal. If the data on the six functional components is accordant and credible, waste management can be easier and effective. Therefore, it is crucial that comprehensive study is conducted to collate necessary data and information for planning purposes. However, this is lacking in Malaysian where landfills were established where the urgent need of disposal arise, that appropriate planning with the considerations of the functional components in solid waste management are not considered.

It is crucial that basic understandings of the planning or approaches are included to carry out efficient and effective SWM system (Pimental, 2008). Therefore, to achieve conservation between environment and development, the guidelines for local authority are beneficial, which are listed as follows:

i Sustainable consumption and development patterns should be encouraged in the

countries, especially in the developing states;

ii Developed nations could lead the sustainable consumption and developmentboth in technologies and financialsupports;

iii In developing countries, it is required to achieve the sustainable consumption and development patterns based on the basic national needs. It is important to avoid unsustainable or high environment costing ways, especially in some industrialized countries during the fast development period (UNEP, 2007).

Sustainable consumption and development strategy aims to achieve balance between the artificial development and natural environment. Currently, the international and national political and economic communities meet some obstacles on the way to the sustainable development, because of some requirements, such as (Pimental, 2008):

i Effective policies to get the citizens involved in decision making;

ii Based on a self-dependence and sustained basic, an efficient economic system can produce surpluses value and knowledge;

iii Facing the increasing tensions from inconsistent development, an efficient social operation system is able to provide the solutions.

iv The eco-system should be respected when an effective production system on the way of development;

v Anefficient technological support system could find out new solutions continually;

vi The international cooperation could encourage sustainable model for international trading and financing; and

vii The self-correction of an efficient administrative system could be done

continuously.

The integrated solid waste management (ISWM) is a new concept related to the ecologically sustainable development. As mentioned above, the rapid urbanization, economic and industrialization development, as well as unsustainable consumption life style resulted in an increasingly amount of solid waste generation becomes much more crucial in nowadays (Maritza, 2010). Furthermore, these impacts caused by the unsustainable development have been affects to the global environment, natural resources, human health, and economic development.

Consequently, in developing countries such as China, Malaysia and India, the traditional dumping to keep safe disposal is already out of date, because it cannot achieve the requirements of sustainable development. It is crucial to find out the reasons of these environmental problems and research proper patterns to achieve the sustainable and conservational development of human society. ISWM system is an advantage option which includes the proper landfill designing and operating. It can contribute to optimize the conservation, environmental protection and sustainable development.

1.3 Waste Disposal Issues in Malaysia

It is reported that 95% of Malaysian MSW are disposed off into landfills. As one of the rapid developing countries in south-east Asia, Malaysia has been practicing both controlled dumping and sanitary landfills as a common way for solid waste disposal. Even though the sanitary landfills are more effective, it is not fully implemented

because of technical and financial limitation (MHLG, 2000).

Based on the statistics done by Sakawi (2010), 230 dumping sites were approved by Malaysian Authorities in 1988. By 2002, only 161 disposal sites remained active in Malaysia. The common characters of landfills in Malaysia are small scale size, improper design and the majority of these landfills were under low-efficient management (MHLG, 2000). It is can be seen that the open dump sites occupies around 50% of total landfills, and the number of well-controlled and managed disposing sites or sanitary landfills is quite small. Nevertheless, the current situation has been improved. Department of Environment (DOE) reported that 54 sanitary landfills were approved and 36 of that have started its operation in 2008. Table 1.4 indicates the targets of Malaysian government to develop new technologies for waste final disposal by 2020 (Fauziah, 2010; Fauziah and Agmuthu, 2006). It shows the sanitary landfill is recommended to be widely applied.

Table 1.4: Methods of Waste Disposal Development in Malaysia

Treatment	Percentage of waste disposed		
	2002	2006	Target 2020
Sanitary landfill	5	30.9	44.1
Inert landfill	0	3.2	9.1
Incineration	0	0	16.8
Composting	0	1	8
Recycling	5	5.5	22
Other disposal sites	90	59.4	0

(Source: Fauziah and Agamuthu, 2006)

Improperly managed landfills may result with various adverse, for examples: jumbled rubbish, the proliferation of insects and rats, and generation of leachate. Therefore, landfills should have sustainable design, construction, operation and management system (UNEP, 2005). According to engineering considerations, small improvements in designing and operating of landfill have been almost succeeded. Sanitary landfills are considered as a high standard landfill application model. After the solid waste going through biological, chemical and physical degradations, the pollutants level can be reduced considerably.

Based on the study by The World Bank (1999), the larger landfills need more investment in improving standards and requirements compared with smaller size landfill sites. However, the unit cost of these improvements (measured per tonne of waste landfill or per head of population served) will decrease with increases in the site size. With a long-term operating lifetime (ten years or more), the landfills sites can get some financial and other benefits. Based on the low transport costs between cities, it could be more economically beneficial, some large regional landfill sites can cater the disposal need for two or more cities. Therefore, it is necessary that sufficient studies on these aspects are carried out in planning and constructing landfills in Malaysia.

1.4 Importance of Research

Recently, SWM not only involved high technologies requirement but also put more concentrations on energy benefit and conservation of environmental balance and human health (Sakawi, 2010). The changes of technologies and management improvements

help the local society to make a better decision which will affect the living residential parties directly.

It is important to figure out proper tools helping making a better option. However, there are not so many research specifically related to decision-making approaches. An appropriate valuation method and effective recorded data may assist the local authorities to improve to make a better choice and to manage the system in a better way.

1.5 Research Objectives

This dissertation is to propose a proper sanitary landfill management and the most appropriate approach to implement an integrated management of municipal solid waste in Malaysia. Therefore, the project focuses on the environmental economic evaluation to learn the economic efficiency of selected sanitary landfills in Malaysia. The necessary research framework is based on a hierarchy of goals, and focus on fourmain aspects, which are stated as follows:

a) To choose a good example of effective landfill, and study the structure and management system of this model.
b) To select a landfill in Malaysia, and research the construction, operation and management of this landfill.
c) To run an environmental economic evaluation based on two above landfills, and to prove which one has more economic efficiency according to Malaysian environment.
d) To give recommendations of improving existing landfill operation and

management system.

These four areas are correlative and mutually supported，so it has to be integrated in order to supply an exhaustive environmental framework for MSW management. According to different local environment, waste components, waste generation rate and socio-economic conditions, each of these five program aspects will be presented in different contents and emphases.

1.6 Scope of Research

This research scope is to find out a proper sanitary landfill modelwith high economical efficiency to accelerate the progress of integrated solid waste management system.

The research involved an economic and environmental evaluation where comparison between a basic semi-aerobic landfill and Fukuoka semi-aerobic landfill were made. For a developing country, especially located in tropical area, the cost of a high efficiency sanitary landfill is higher compared to a simple landfill or open dumping site. However, an effective sanitary landfill has a high environmental benefit and can provide a better monetary value in a long-term. Therefore, constructing effective sanitary landfills will enhancean integrated MSW treatment and management system towards sustainable development.

1.7 Research Limitations

The data collected in this study are mainly obtained from interviews, internet database and emails corresponds. The data gathering is limited to private and confidential issues of landfills operators to avoid commercial competition. On the other hand, many data on waste generations are based on estimated figures by relevant authorities. Therefore, the waste management situation and economic analysis of current situation in this city is limited.