CHAPTER 4 : DISCUSSIONS

4.0 Introduction

This section describes and discusses the current situation on solid waste management in terms of the practices, issues and observed trends. This description and discussion is important to derive an effective policy framework for solid waste management that is well-founded on established facts (Wescott, 1992).

4.1 Existing Practices in Solid Waste Management

The existing practice for solid waste management has been grouped under five functional categories and discussed accordingly. This is to help identify possible areas for improvement in the overall existing solid waste management process, which in turn is expected to elucidate fundamental issues, related to solid waste management (Tchobanaglous *et al.*, 1993). These five functional categories are :-

I. Solid Waste Generation & Composition
II. Solid Waste Handling at Source
III. Solid Waste Collection & Transportation
IV. Solid Waste Treatment & Resource Recovery
V. Solid Waste Disposal

4.1.1 Solid Waste Generation & Composition

Waste generation consists of identifying materials or objects that are no longer considered as of value and which is subsequently disposed (Tchobanaglous *et al.*, 1993). Consistent data on solid waste generation rates in Malaysia are lacking due to an absence of established activity in this area. The latest available national solid waste generation data in 1998 indicates that Malaysia generates approximately 15.2 tonnes of waste per day for an estimated population of 16.8 million people (Table 4-1) (MHLG, 1999).

Table 4-1 : Estimated Solid Waste Generation in Malaysia in 1998

State	Estimated Population	Waste Generated (tonnes/day)	Amount collected (tonnes/day)
Selangor	1583572	2375	1900
Kuala Lumpur	1446803	2257	2023
Sabah	2115546	1481	1037
Sarawak	2007528	1405	984
Perak	1618483	1295	906
Johor	1612650	1290	903
Kedah	1581483	1265	885
Pulau Pinang	1290924	1033	723
Kelantan	1041311	833	583
Pahang	634660	508	358
Melaka	611481	489	342
Terengganu	583907	467	327
N. Sembilan	578035	462	323
Perlis	77650	62	43
Labuan	66146	46	32
Total	**16850179**	**15268**	**11369**

(MHLG, 1999)

Thus in 1998, Selangor had the highest solid waste generation of 2375 tonnes /day followed by Kuala Lumpur at 2257 tonnes /day while Labuan had the lowest solid waste generation of only 46 tonnes/day. National solid waste generation is projected to increase from 2.5 million tonnes in 1991 to 3.9 million tonnes in 2000 (Table 4-2).

Table 4-2 : Projected Solid Waste Generation in Malaysia

Year	Population (million) (Increase - 3%/year)	Waste Generation rate (kg/cap/day) (increase at 2% /cap/ year)	Total amount (million tonnes)
1991	13.272	0.7	2.5
1992	14.139	0.7	2.6
1993	14.563	0.7	2.8
1994	15.000	0.8	2.9
1995	15.450	0.8	3.0
1996	15.913	0.8	3.2
1997	16.391	0.8	3.4
1998	16.882	0.8	3.5
1999	17.389	0.8	3.7
2000	17.911	0.9	3.9

(MHLG, 1999)

The per capita solid waste generation rate in the 1980s was 0.5/cap/day which increased to 0.75 kg/cap/day in the 1990s and currently in 2000 is estimated at 1.0 kg/cap/day (Sekarajasekaran, 1982 and Nasir *et al.*, 2000).

The availability of comprehensive data on solid waste composition on a national scale is limited. A recent study by the World Bank reported that the solid waste composition in Malaysia was dominated by organic waste at 43.2% followed by paper at 23.7% in the total waste stream (Table 4-3) (Hoornwerg & Thomas, 1999).

Table 4-3 : Solid Waste Composition in Malaysia

Waste Composition	Proportion (%)
Organic	43.2
Paper	23.7
Plastic	11.2
Glass	3.2
Metal	4.2
Others	14.5
Total	100

(Hoornwerg & Thomas, 1999)

However, solid waste composition studied for individual areas are also presented below (Table 4-4, Table 4-5 & Table 4-6). The waste composition for the same area may differ due to differences in methodology, seasonal fluctuation and time of study.

Table 4-4 : Waste Composition in Selected Areas in Malaysia in the 1980s

Area	Kuala Trengganu (Rural)	Seremban (Semi-urban)	Petaling Jaya (Urban)
Year	1983	1983	1984
Waste Composition			
Organic	66.0	35.0	48.3
Paper	15.0	44.0	23.6
Plastic	3.5	5.0	9.4
Glass	1.0	2.0	4.0
Metal	5.0	4.0	5.9
Others	9.5	10.0	8.8
Total	100	100	100

(Adapted from ABC, 1988)

Table 4-5 : Waste Composition in Selected Areas in Malaysia in the 1990s

Area	Muar (Rural)	Seremban (Semi-urban)	Kuala Lumpur (Urban)
Year	1994	1994	1994
Waste Composition			
Organic	63.7	35.0	48.4
Paper	11.7	10.0	30.0
Plastic	7.0	2.5	9.8
Metal	6.4	5.0	4.6
Others	11.2	25.0	7.2
Total	100	100	100

(Nasir *et al.*, 1998)

Table 4-6 : Waste Composition Trends for Kuala Lumpur from 1975-2000

Year	1975[1]	1980[1]	1990[1]	1995[1]	2000[2]
Waste Composition (%)					
Organic	63.7	54.4	48.4	45.7	68.4
Paper	7.0	8.0	8.9	9.0	6.4
Plastic	2.5	0.4	3.0	3.9	11.8
Glass	2.5	0.4	3.0	3.9	1.4
Metal	6.4	2.2	4.6	5.1	2.7
Textile	1.3	2.2	-	2.1	1.5
Wood	6.5	1.8	-	-	0.7
Others	0.9	0.3	-	4.3	7.1
Total	*100*	*100*	*100*	*100*	*100*
Moisture Content				65	58.9
Density (kg/m^3)				230	302.4

[1](Nasir *et al.*, 1998) & [2](Nasir *et al.*, 2000)

The results above combined with approximate average estimations indicate the following interim inferences in terms of waste composition in Malaysia :-

I. Waste composition in Malaysia is dominated by organic waste comprising almost 50% of the total waste stream. Average organic waste composition in the 1980s and the 1990s was approximately 50% (Table 4-4 & Table 4-5) while the average organic waste composition in Kuala Lumpur in 2000 was approximately 68% of the total waste stream.

II. Waste composition in rural areas contain higher amounts of organic and lower amount of paper and plastic than in urban areas (Table 4-5 & Table 4-5).

III. The quantity of organic waste in Kuala Lumpur shows a decreasing trend from 1975 to 1995 from 63.7% to 45.7%, which is 18% reduction in 20 years. This has been attributed to the increase in paper and plastic waste in the waste stream (Yani *et al.*, 2000). However, the composition of organic waste in 2000 has suddenly increased to 68.4% of the total waste stream. One possible reason could be due to the reduction in paper, plastic and glass waste due to increased recycling activities thus increasing the total organic waste composition in the waste stream (Table 4-6).

IV. Moisture content in the waste stream in Kuala Lumpur is estimated at 62% while the waste density is estimated at 266 kg/m^3.

4.1.2 Solid Waste Handling at Source

This activity involves management of waste until they are placed in storage containers for collection (Tchobanoglous *et al.*, 1993). Waste handling at source is important especially in Malaysia due to the high biodegradability of wastes, which results in odor. Source separation of recyclables at households is virtually non-existent except in the Majlis Perbandaran Petaling Jaya (MPPJ). This was first introduced in 1990 and involved the separation of waste at source with curbside collection of recyclables. Consequently, in 1996 MPPJ introduced its' Yellow Box Recycling Program where 10,000 households were given recycling boxes for residents to participate in source separation (Kamariah, 1997). Residents usually own the normal storage containers while communal facilities are provided and maintained by the Local Authorities (LAs). The existing situation of storage containers for the various premises is as the following :-

Table 4.-7 : Existing storage container for various premises in Malaysia

Premises	Storage Containers
Residential area (low rise)	Currently there are no standard storage containers for individual households. The containers usually used are metal, plastic and rubber containers. Sometimes rattan baskets and plastic bags hung on fences is the practice.
Residential area (high rise, flats and apartments)	These premises use communal bins that are provided by the management or the LAs. The communal bins use are metal bins, stationary concrete bins and big bins collection vehicles.
Commercial areas	These areas include shop houses, markets and shopping complexes and are provided with communal bins by the LA. However some of these commercial areas also use plastic and rubber bins.
Institutional areas	These areas include government offices, schools, hospitals and public facilities and are provided with communal bins by the LA.
Industrial areas	Industrial areas include factories and are provided communal bins by private contractors.

Adapted from (MHLG, 1984) & (ABC, 1988)

However with the initiation of national privatization of solid waste, the private waste managers are currently planning to upgrade this storage facilities by providing or leasing suitable standard types and size of containers to each premises. Therefore the expected change in storage containers for the various premises is as the following :-

Table 4.-8 : Future storage container for various premises in Malaysia

Premises	Storage Containers	Container Size
Residential area (low rise)	Plastic Mobile Garbage Bins (MGB)	120 Litres (L) or 240 L or 360 L
Residential area (high rise, flats and apartments)	Waste Drum Or Stationary Compactor	8000 L -25,000 L or 660 L – 1500 L
Commercial areas (shopping complex, office complex & business centers)	Roll-on Roll Off Containers (RORO) or Bulk Plastic or Metal Container or Compactor Container	8000 L -25,000 L or 660 L – 1500 L
Institutional areas	Roll-on Roll Off Containers (RORO) or Bulk Plastic or Metal Container	8000 L -25,000 L or 660 L – 1500 L
Industrial areas	Roll-on Roll Off Containers (RORO) or Bulk Plastic or Metal Container	8000 L -25,000 L or 660 L – 1500 L

(Adapted from AFSB, 2000b)

The advantages of the new storage containers in the Malaysian solid waste management scenario are :-

1. The Mobile Garbage Bins (MGB) designed for residential areas is advocated as one of the best option for storage due the following :-
   - Designed from strong High Density Poly Ethylene (HDPE) plastic and equipped with axle and wheels for mobility.
   - Capable to withstand heat in the range of $40^{o}C$ - $80^{o}C$
   - Estimated life span of 12 years.
   - Prevents the spillage of leachate.
   - Reduces odour through the attached lid system.

2. The Roll- On Roll Off Containers (RORO) and the Stationary Compactors are designed for commercial, institutional and industrial areas and is advocated due to the following :-
   - Ability to contain large amounts of waste.
   - Minimizes collection workers through the single man operator system.
   - Prevents leachate or spillage of waste.
   - Minimizes area required for storage area.

3. The Waste Drum System is designed for high rise residential and commercial areas and is an advanced system due to the following :-
   - Doubled sealed construction prevents garbage spillage.
   - Automatic disinfection promotes environmental hygiene.
   - Compressed storage extends storage capacity.
   - Flexibility in indoor and outdoor installation.

4.1.3 Solid Waste Collection & Transportation

The collection of waste involves the gathering and transport of solid waste to intermediate processing plant or to final disposal (Tchobanoglous *et al.*, 1993). Approximately 20-80% of the annual budget of LA in Malaysia are spend on collection activities. Front curbside and back lane collection of wastes is the norm for individual residential areas while the communal collection system is practiced for areas that are less accessible to collection vehicles such as villages (MHLG, 1984). The collection frequency is about 3 times a week in residential areas and every day for commercial and institutional areas. The types of collection vehicles used by the LA currently are the compactor vehicle, side loader vehicles without compaction units and the open trucks that are usually used for garden waste. It is estimated that only 70% of the total solid waste generated in Malaysia are collected, the remaining 30% is diverted by recycling as well as due to illegal dumping. Consequently, with the initiation of national privatization of solid waste, the private waste managers are currently planning to upgrade collection services and the collection vehicles that are currently utilized. Generally, there will be two types of collection service which are kerbside collection where waste will be collected from premise to premise and the bin point collection where collection will be only done at the bin points. Kerbside collection will be done in landed residential areas such as terrace house, semi-detached and bungalows as well as in shop houses where a bin point is not available (AFSB, 2000a).

The proposed collection standard level of service and the types of collection vehicles are shown in the Table 4-9 and Table 4-10.

Table 4-9 : Proposed Collection Service Standard

Services	Regularity
Residential areas -terrace houses, bungalow and semi-D - high-rises	 - 2x/week or 3x/week - 6x/week
Commercial	- 6x/week
Institution	- 6x/week
Market	- 7x/week excluding wet markets not privately owned
Public Places - Grass cutting - Cleansing of public places - Grass cutting on curbsides	 - 2x/week - Daily or as necessary - 2x/month

(AFSB, 2000b)

Table 4-10 : Proposed Collection Vehicles

Type of waste	Collection Vehicle
Domestic, commercial and institutional waste	1. Rear end Loader Compactor (short term plan) 2. Front end loader Compactor (long term plan) 3. Side loader Compactor (long term plan) 4. Arm roll
Construction waste	1. Arm roll (short term plan) 2. Skip loader (long term plan)
Bulky and garden waste	1. Open tipper

(AFSB, 2000b)

However, the compactor is expected to be the most common collection vehicle to be used except in cases where a stationary compactor or RORO is provided which is handled by an Armroll. In the future the private waste managers are planning to implement the one man operator system where there is only one crew allocated for each collection vehicle (compactor) as compared to the current system of 4 crew for one compactor (AFSB, 2000b).

4.1.4 Solid Waste Treatment & Resource Recovery

This activity involves the recovery of separated materials, the recycling of solid waste components and the transformation of wastes to resource that occur away from the source of generation (Tchobanoglous *et al.*, 1993). Currently, the only incinerator is in Kuala Terengganu, which has a capacity of 100 tonnes /day since 1987 (ABC, 1988). However, the incinerator is currently not utilized due to a shortage of waste material for incineration. Furthermore resource recovery from solid waste also occurs at a minimal level. The national recycling rate is estimated at 1 –2 % of the total waste stream (Chamhuri, 2000). This is mainly done through informal recycling by landfill scavengers and municipal waste collection crews. Other areas of recycling are lead by the Local Authorities and NGOs. In 1993 the Ministry of Housing and Local Government (MHLG) initiated the first National Recycling Program through which 23 LAs were involved. The main objective was to reduce waste disposal as well as to promote the concept of resource recovery of waste (Kamariah, 1994). However, the performance of these LAs in terms of recycling has been generally poor and is attributed mainly to the inability to maintain the recycling programs. Subsequently, the MHLG launched a second National Recycling Program in December 2000 (Kalai, 2000).

Currently, in Petaling Jaya it is estimated that more than half of the collection crew is involved in scavenging of recyclable items. They recycle approximately 24.5 tonnes of waste per day or 5.2% of the total waste disposed. The collection crew (approximately 4 person per crew) earns about RM 2500/day. Dumpsite scavengers in Petaling Jaya on the other hand recycle about 3.9 tonnes of waste per day or almost 1% of the total waste disposed.

Consequently the total resource recovery from scavenging by the collection crew and at the dumpsite is about 28.4 tonnes of waste per day or about 6% of the total waste stream (Nasir *et al.*, 1996). A more recent study has revealed that the Yellow Box System in MPPJ for the period of June 1999 – November 1999 managed to recover 50,660 kg of recyclables which is worth about RM4000 (Table 4-11) (Yani *et al.*, 2000).

Table 4-11 : Recylables from the Yellow Box System from June – November 1999.

Recyclables	Total (kg)	% of recyclables	Price/kg	Worth (RM)
Paper	24590	48.5	0.10	2459.00
Glass	13150	26.0	0.05	657.50
Metal	8170	16.1	0.10	817.00
Plastic	4750	9.4	0.05	237.50
Total	50660	100		4717.00

(Modified from Yani *et al*, 2000)

In Kuala Lumpur, it is estimated that about 3000 tonnes of waste is generated per day in 2000. From this amount approximately 672.3 tonnes or 22% of the total waste stream are recyclable items. Paper forms 41% of the total recyclable items. The total recyclable items are estimated to be worth about RM 55260 (Table 4-12) (Yani *et al.*, 2000).

4-12 : Estimated Recylables in Kuala Lumpur for 2000.

Recyclables	Total (kg/day)	% of recyclables	Price/kg	Worth (RM/day)
Paper	276300	41.1	0.10	27630.00
Glass	119730	17.8	0.05	5986.50
Metal	156570	23.3	0.10	15657.00
Plastic	119730	17.8	0.05	5986.50
Total	672330	100		55260.00

(Modified from Yani *et al*, 2000)

Furthermore, resource recovery by scavengers alone at the dumpsite in Kuala Lumpur and Petaling Jaya is estimated at 11750 kg/day and 5152kg/day respectively (Nasir *et al.*, 1996).

In conclusion, the above results on resource recovery through scavenging and recycling indicate the following :-

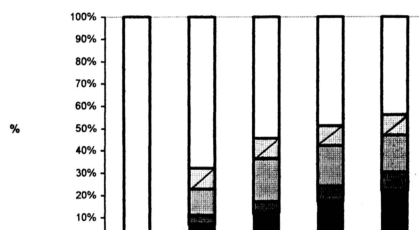
I. Formal resource recovery through source separation and recycling is minimal. The average national recycling rate is estimated at 1-2%. The calculated recycling amount through the Yellow Box System was estimated at 0.3 tonnes of waste per day (Table 4-11).

II. Informal recycling in MPPJ through scavenging by waste collection crews and dumpsite scavengers recycle approximately 28.4 tonnes of waste per day or about 6.0% of the total waste stream.

III. The amount of recyclable material out of the total waste stream in Kuala Lumpur is about 22% of the total waste stream and is worth about RM 55,000. Paper forms the highest constituent at 41%.

IV. Based on the figures for Kuala Lumpur and Petaling Jaya it is anticipated that the potential for maximum resource recovery through recycling is about **22%**. Furthermore, the potential for resource recovery through scavenging is about **6%**. Resource recovery through recycling is therefore a growing industry with numerous stakeholders from the public, collection to the scavengers.

Notwithstanding, the draft Concession Agreement between the private waste managers and the Government, certain targets for waste diversion and resource recovery is under discussion to be fulfilled by the private waste managers. These interim targets aim to achieve a 3% recycling rate in 2001 and consequently a 1% increment every year to achieve a 22% recycling rate in 2020 at the end of the concession period (AFSB, 2000b).



	2001	2005	2010	2015	2020
Sanitary Landfilling %	97	67.9	54.5	48.9	44.1
Inert Landfilling %	0	9.2	9.1	9.1	9.1
Incineration %	0	11.9	19.4	18	16.8
Composting %	0	4	5	7	8
Source separation/Recycling %	3	7	12	17	22

(AFSB, 2000b)

Figure 4-1 : Interim Waste Diversion, Treatment & Disposal Trends

Therefore in anticipation of these interim targets that are still under discussion, the private waste managers are planning 3R (Reduce, Reuse & Recycle) programs that cover the following :-

I. Community Programs where a community recycling center and a mobile recycling will be established.

II. Institutional, Commercial & Industrial (ICI) Program where recycling activities will be targeted at these stakeholders.

III. School Programs where the students will be guided in recycling with the assistance of the Ministry of Education.

IV. Public communication and participation program where awareness building initiatives will be launched to educate and instill good habits in waste management.

V. Other areas of resource recovery will be in terms of constructing waste management facilities such as :-

- Transfer stations which are centralized facilities for the transference of waste prior to final disposal. This will be initiated for collection areas that are more than 25 km from the landfill site. In addition, separation and recycling of waste will be carried out here. Four levels of transfer station will be planned based on capacity.
- Materials Recovery Facilities (MRF) will be installed in areas that are expected to capture a high amount of recyclables. Two types of MRF will be considered which are the manual and fully mechanical type.
- Incinerators will be considered for areas with land scarcity problems.
- Composting of green waste and household organic waste is planned at landfill sites.

4.1.5 Solid Waste Disposal

The final functional category of solid waste management is disposal. The most common method of solid waste disposal in Malaysia is through landfills. The majority of the existing landfills in Malaysia are open dumping grounds with minimal environmental control measures. In 1990, there were about 230 landfills in Malaysia with about 60% of them being open dumps (Nasir et al., 2000). However in 1998 the total number of landfills in Malaysia were at 177 with about 51% of them being open dumps. There were 90 open dumps, 76 landfills with controlled tipping and 11 sanitary landfills (Table 4-13). Pahang, had the highest number of landfills and open dumps among all the States followed by Johor.

Table 4-13 : Number and type of landfill sites in Peninsular Malaysia (1998)

State	Open Dumps	Controlled Tipping	Sanitary Landfills	Total
Perlis	0	1	0	1
Kuala Lumpur	0	0	1	1
Pulau Pinang	0	2	1	3
Melaka	2	2	1	5
Kedah	7	5	1	13
Negeri Sembilan	7	6	0	13
Kelantan	14	3	0	17
Selangor	7	9	2	18
Terengganu	9	8	1	18
Perak	7	17	2	26
Johor	15	15	0	30
Pahang	22	8	2	32
Total	**90**	**76**	**11**	**177**

(MHLG, 1999)

The total average cost for landfilling is estimated at RM7.20 per tonne. The average charges for household waste is RM2.00 per tonne, commercial waste is at RM3.40 per tonne and industrial waste at RM3.50 per tonne (Nasir et al., 1998).

The most modern sanitary landfill in Malaysia is the Air Hitam landfill in Selangor operated by World Wide Sita. The tipping fees for waste disposal here is at RM25.00 per tonne of waste. The landfill has been in operation since 1995 and has catered for more than 1.5 million tonnes of solid waste up till now. The landfill is expected to achieve its full capacity in 2004 (AFSB, 2000b). The features of the landfill include a liner, gas ventilation and leachate collection system. However, even with these advanced features the landfill has not been able to meet the DOE Standard B for effluent discharge for its leachate quality (Nasir, 2000).

Under the national privatization move, existing landfills taken over by the private waste managers are divided into type Site A and Site B. Site A landfills are landfills used by the private waste managers for less than 3 years and are considered temporary landfills which are closed without any treatment. Site B landfills on the other hand are landfills which have been used for more than 3 year and which are required to be upgraded to sanitary landfills under the Concession Agreement (pers. comm, Zakiah, 2000).

In conclusion, though landfilling is currently the most common form of waste disposal, problems of land scarcity in urban areas are beginning to reduce the viability of this option in solid waste management. Therefore supplementing landfilling with incineration is currently being considered as a viable option (pers. comm, Engku Ezman, 2000). Furthermore, the interim waste management targets set by the government in the Concession Agreement with the private waste managers have identified to reduce waste disposal by landfilling to 44% in 2020 where incineration and recycling will compliment the waste management system at 17% and 22% respectively.

4.2 Issues & Trends of Solid Waste Management in Malaysia

This section discusses the issues and trends associated with solid waste management in Malaysia. The purpose in identifying such issues and trends is to present a comprehensive perspective on the direction and needs of the solid waste management system in Malaysia. This is hoped to ultimately lead to the development of a policy approach that meets this need in a sustainable manner taking into account the environmental, economic and social linkages. The main issues and trends in relation to solid waste management in Malaysia are discussed based on the framework of the functional element of the solid waste management system. Furthermore certain key priority issues in solid waste management that are expected to significantly influence the entire framework are also discussed. These are summarized below :-

I. Solid Waste Generation & Composition

II. Solid Waste Handling at Source

III. Solid Waste Collection & Transportation

IV. Solid Waste Treatment & Resource Recovery

V. Solid Waste Disposal

4.2.1 Issues and Trends in Solid Waste Generation & Composition

1. Lack of Data

Data on solid waste generation, composition, sources and types are critical in determining fundamental aspects of an integrated solid waste management system. Good data on solid waste can help establish sound targets for policy, policy instruments and strategies for implementation, monitoring and enforcement. This has been recognized as a fundamental aspect to improving environmental policy formulation and thus shifts the policy formulation process from guestimates to concrete solutions (Matier, 1995).

Currently, there is a general lack in good, accurate and consistent data on solid waste in Malaysia at a national level. The available data are largely scattered and is at a micro level. A high level of inconsistency has been reported in data presented by academics, local authorities and the private waste managers. Notwithstanding that the implementation of waste management facilities such as incinerators require data collection through the EIA process. However, this is again on a micro level while waste management decisions affect the system on regional levels. Consequently, this lack of data affects the decision on waste management system and the choice of instruments to be implemented in the country. The lack of data also hinders the formulation of practical solid waste management policy targets, in terms of waste diversion and instruments.

Therefore accurate, systematic and consistent data on solid waste is deemed necessary in the following priority areas :-

I. National and regional waste generation rates

II. National and regional waste composition patterns

III. Breakdown on waste types and source

IV. Physical, chemical and biological properties of waste.

V. Level of hazardous waste routing into the solid waste management system

VI. National and regional waste diversion patterns

2. Increasing Waste Generation

Through out the world a common problem in solid waste management is the trend of increasing solid waste generation especially in connection with population and economic growth (Curzio *et al.*, 1994). Malaysia seems to be no different as the solid waste generation has increased from 2.5 million tonnes/year in 1991 to 3.9 million tonnes/year in 2000. This represents a 56% increase in solid waste generation within 9 years.

This increasing waste generation trend may very well mean that solid waste generation in Malaysia may double in the next 10 years. However, as of the year 2000, there are no measures to tackle this increasing problem of waste generation at source in term of formal policies, legislation or changing public consumption patterns. Most of the efforts have been targeted at solid waste management after production. Consequently, Malaysia may face a future of trying to cope with increasing waste generation by continually finding means of improving collection, treatment and disposal if this root problem is not addressed immediately.

3. Patterns of Waste Composition in Malaysia

Differences in waste compositions means that different and distinct waste management approaches may be required to tackle the waste management problem (Beukering *et al.*, 1999). This relates to targeting focus areas for management as well as in deciding the suitability of waste management facilities such as incinerators. Waste composition patterns also help to determine waste diversion targets in terms of recycling and composting programs and ensuring that these targets are realistic and achievable (Tchobanoglous et al., 1993). Typical to most Asian developing countries, Malaysian solid waste composition constitutes mainly of organic waste (Agamuthu, 1997). Organic components in Malaysia can range from 40%–70% while the recyclable components (paper, plastic, glass and metal) can range from 20%-40% (Table 4-3 & 4-5). Furthermore the moisture content in the waste is also high at about 65% due to the wet climatic conditions.

Consequently, Malaysia's future strategies for solid waste management must be based on its local waste composition patterns. There are fundamental differences between waste composition in developed countries and developing countries. As a result while lessons can be learned from the experience of developed countries, the specific strategies to be adopted should be based on local conditions. There are developed countries such as Spain and Israel that have similar waste composition patterns with Malaysia. Malaysia can learn from the experiences of these countries taking into account other local factors.

4.2.2 Issues and Trends in Solid Waste Handling at Source

1. Source Separation of Waste.

Separation of waste at source before they are collected is one of the most critical steps in solid waste management next to source reduction. This activity aids tremendously in the recovery and recycling of materials (Tchobanoglous et al., 1993). However, currently source separation of solid waste is not done in Malaysia except in MPPJ, which has been moderately accepted by the residents. Two of the factors that contributed to the participation by the residents were the provision of containers for the recycling activity as well as the provision of curbside collection of these recyclables. It was anticipated that the inconvenience of implementing the drop off center system might reduce the participation of the public in the source separation program (Kamariah, 1994). However, a recent study on the willingness of residents in the Klang Valley to participate in activities such as recycling and source separation, identified that only 55% of the respondents were willing to participate in such programs (Irra, 1999). Consequently, the issues in regards to source separation of waste are the lack of infrastructure and incentive to initiate this activity. Infrastructure in this context refers to the provision of containers and vehicles for source separation. The incentive or driving force for this activity has to do with changing public habits and getting them to participate in the activity. Source separation of waste has been widely ignored due to a lack of national drive in this direction. Hence the setting of national targets for such activity is essential to ensure that performance in this area can be monitored. Source separation of waste has the potential to recover the waste from the waste stream prior to being mixed and contaminated, which then results in expanded energy for recovery.

4.2.3 Issues and Trends in Solid Waste Collection and Transportation

1. Waste Collection Efficiency & Effectiveness

In the entire solid waste management system, collection cost is considered the most expensive among all the other activities. Waste collection efficiency has to do with maximizing the available resources in the solid waste management system and producing a productive service. This is increasingly becoming important due to rising cost in fuel transportation and labour (Tchobanoglous et al., 1993). Collection efficiency therefore refers to maximization of vehicle capacity and labour. Collection effectiveness on the other hand refers to the ability to achieve the goals of the collection activity, which mean the percentage of waste collected versus waste generated.

In Malaysia, collection cost take up 20 –80% of the existing LAs budget which means that this is an area of importance in the waste management system. Collection efficiency also becomes important in Malaysia when considering that a large portion of the waste is organic, which are susceptible to decay thus resulting in problems of odour. Currently, there is no data on the subject though this is an area that has been identified for improvement (ABC, 1988). Collection efficiency ultimately refers to the collection system and the collection routes. Consequently, research in the area of collection systems and collection routes is deemed important to ultimately achieve an efficient solid waste management system. This means that the type of collection system, the minimum number crews and the best possible routes to save time and increase productivity should be analyzed and incorporated as part of the integrated solid waste management system.

If current collection effectiveness in solid waste management is estimated at 70% and assuming a national recycling rate of 3% then the remaining 27% that is not collected is anticipated to be disposed illegally. Illegal disposal of waste is a national problem especially in urban areas as it not only causes environmental pollution but also represent time and energy lost in remediating the problem. Consequently, one area that has been identified as lacking is the insufficient enforcement in the area of illegal dumping (Jamaluddin, 1998). This is undoubtedly understandable due to the heavy workload of the municipal authorities and the intricacies in attempting to track down the guilty party. However, enforcement of solid waste management is anticipated to become more and more important as regulation and standards become more stringent. Furthermore, in the event that the proposed Solid Waste Act and subsequent regulations is enacted, this will require enforcement activities be carried out since legislation without enforcement renders the entire process redundant. Consequently, provision of sufficient personnel and funds as well as developing close partnerships with other government institutions will be important for any proposed government institution to manage solid waste for the country.

4.2.4 Issues and Trends in Solid Waste Treatment and Resource Recovery

1. Waste Management Options

The main solid waste management options are :-

I. Waste to Energy technologies, which include direct incineration, refuse derived fuel (RDF), pyrolysis and bio-gasification.

II. Recycling

III. Composting.

IV. Landfilling which will be considered further under Final Disposal

International trends in developed countries reveal that the most common waste management option currently is landfilling. However trends also indicate that most of these countries are moving away from landfilling to other options such as energy recovery and recycling (McCarthy, 1994). This is because landfilling represents the lowest form of waste management option in the waste hierarchy due to the fact that the waste resource are lost in final disposal as well as due to emission of greenhouse gases.

Table 4-14 : Waste Management Option Trends

Country	% in Landfilling	% in Energy Recovery	% in Recycling & Composting
EU (1995)	67	18	15
UK (1997)	83	8	9
USA (1997)	55	17	28
Malaysia (2000)	97	0	3

The most common form of waste management option currently in Malaysia is in landfilling which constitutes almost 97% of the total waste stream. Under the draft Concession Agreement with the private waste managers, the targeted waste management option for 2020 are 53% landfilling, 30% recycling and composting and 17% incineration. It is not known how these figures were derived but two key issues in the form of waste management options projected for Malaysia are discussed.

The first is the choice of the waste management options cannot be always based on the waste hierarchy. This is because increasingly it is being recognized in the developed countries that the waste hierarchy may not be applicable in all situations and in all countries.

In some cases it may be better to choose a waste management option other than recycling and reusing because the impacts from treating it could cause more environmental pollution. An example of this is that sometimes it may be better to landfill a beverage container than recycling it due to the energy required and the chemicals used in the recycling process. At the end of the day the problem of disposing the waste container could just be transferred to a water pollution problem and the loss of other raw materials used to supply the required energy. Furthermore, the waste hierarchy only considers environmental impacts though in reality the social and economic criteria play a major role in the waste management process. Consequently, the waste hierarchy should be considered as a menu of options – "It is not a question of good and bad waste management options or technologies. Rather, each option is equally appropriate under the right set of conditions addressing the right set of waste stream components" (Schall, 1995).

The second key issue is that in Malaysia, careful thought must be given in the integration of its waste management option policies since the entire system is interconnected, which will be discussed further under Establishing Priorities. This refers to the initial investment of a particular waste management facility early in Malaysia's waste management evolution that would subsequently entail a high level of commitment to keep the system running. A key issue is the fact that if the waste diversion targets for recycling & composting are 30% in 2020, can this at the same time ensure sufficient supply of waste for the proposed capital intensive incinerators? The alternate scenario is to provide the incinerators with sufficient supply of waste and neglecting the waste management options of landfilling, recycling and composting since a high cost has already been invested in these incinerators. A good example is the existing incinerator in Kuala Terengganu, which currently does not have sufficient supply of waste.

Incineration, Recycling & Composting

Incineration in most developed countries is complemented by energy recovery. It is unknown if similar mechanisms are in place for Malaysia. Incineration without energy recovery will mean the equivalent of landfilling only at a higher cost since the waste materials is not recovered for further use. Current high capital investment in other forms of energy facilities in Malaysia does not provide an encouraging prospect for energy recovery from incineration. This needs to be addressed in a national policy taking into account Malaysia energy policy or else the action to invest in incineration for energy recovery might prove a failure if there is no market. Incineration as an option for waste treatment and resource recovery may seem attractive for urban centers but the technology is capital intensive with high maintenance cost. Furthermore, the moisture content in Malaysian waste is also estimated to be high due to the wet climate. Such basic differences with countries that are deeply involved in incineration entails that the incineration option is considered with care.

Recycling has been on the international agenda for some time now and involves source separation of waste, scavenging and material recovery facilities. Recycling in the developed countries has been advocated primarily due to political pressure from the public in terms of increasing environmental concerns and standards as well as due to economic pressure from the increasing cost of land shortage (Beukering *et al.*, 1999). Furthermore the larger portion of recyclable materials in the waste stream also makes recycling a more viable waste treatment option. In recent years there has been an increasing interest in recycling in Malaysia. This has mainly to do with the current direction in choosing incineration as a waste management option.

The Malaysian government is currently planning to construct two incineration plants in Kuala Lumpur and Labuan respectively pending the approval of the EIAs. Nevertheless, there have extensive debates on the subject especially by the NGOs on the use of incineration. This is mainly attributed to the concern from the emission of dioxins and furans from incinerators that may be of health concerns. Consequently, as an alternate option to incineration, recycling has been advocated to reduce the waste quantities.

However, there are certain issues that deserve consideration in attempting to promote recycling as a main form of waste management. Recycling in the developed countries such as the US and EU are deemed more viable due to establishment of national legislation and targets as well as due to the larger amount of recyclable materials in the waste stream as compared to Malaysia which is still uncertain (Table 4-15).

Table 4-15 : Percentage of recyclable materials, recycling goals & existing rates

Country	% of recyclable materials	Recycling Goals	Mechanism	Existing recycling rates
UK	53%	25 % by 2005	Waste Strategy 2000	10%
Israel	41%	25% by 2007	Recycling Law 1998	10%
Spain	41%	8-14% by 2001	Packaging Waste Law 1997	3%
Malaysia	20%-40%	None	None	3%

Consequently, the lack of comprehensive data on the composition of recyclable materials in Malaysia makes it difficult to set realistic targets for recycling. The worst case scenario entails a maximum recycling rate of only 20% of the total waste stream with the implication that recycling as a treatment option to substantially divert waste from the waste stream is small.

Furthermore, most of the developed countries have already enacted legislation and policies to ensure that recycling becomes a viable option for waste treatment and resource recovery. Even with this mechanisms in place the existing rates achieved are about 10% only, while on the other hand Malaysia is still in the early stages of enacting its legislation and still has no formal national policies.

Scavenging plays an important function in recycling and resource recovery in Malaysia where in Petaling Jaya for example, it is estimated almost 6% is recovered from the total waste stream destined for final disposal. However, this important function has largely gone unappreciated due to the health hazards posed to the scavengers. While the safety and health aspects of scavenging must be given due consideration, it is also considered important that existing function of scavengers be recognized in the solid waste management system and serious consideration be given to incorporating them formally in the waste diversion activity.

The Malaysian waste composition contain a high amount of organic waste that warrant the option of composting as a waste treatment and resource recovery to be considered seriously. Current thinking along this line deems that the option of composting is not feasible due to the high cost and low market for the product. However, the very fact that countries such as Spain and Israel which have high content of organic waste at about 45%, are seriously looking into the option of composting, warrants that work on incorporating composting technologies be intensified in Malaysia.

2. The establishment of priorities

The establishment of priorities determines the choice of waste treatment and resource recovery options. This involved whether a country or a region chooses to favor recycling over incineration or composting over other options. Whatever the choice, this must be done in an established and planned manner. Consequently, priorities for waste treatment options must be established and communicated formally. Priorities are established by deliberating which component between the environment, economics, social and political areas are esteemed. Furthermore, it is important that all the relevant stakeholders are involved in establishing these priorities (Tchobanoglous *et al.*, 1993).

In Malaysia there is currently no such clear priorities for waste treatment and resource recovery options. As such this often leads to ad-hoc decision on the waste management options with minimal participation from all the stakeholders. Furthermore, the lack of stakeholder participation in establishing these priorities is also evident. Thus, stakeholders are generally surprised when decision regarding the choice of waste treatment options are made public. A clear example of this was in the decision to implement incinerators in Kuala Lumpur as a waste treatment option. Undoubtedly, it raised controversy when the matter was revealed in a public forum in GLOBAL, which was televised nationally. The fact that serious deliberation might have been conducted by the government prior to choosing such an option is lost when these priorities were not communicated to the various stakeholders. Consequently, in integrated solid waste management, priorities provide direction and the basis for decision making on a national scale with the involvement of all the stakeholders which again translates to the need for a national policy.

3. Markets for Resource Recovery

The role of economics in solid waste management should always be kept in mind. Market forces often drive business and consumer behavior, which in turn influence waste generation. The importance of economics in resource recovery is also well evident in the case of recycling, composting and incineration. The current practice of scavenging is largely economic driven since it provides a source of revenue to the people involved (Chamhuri *et al.*, 2000). It has long been recognized that market prices for the recovered materials has a strong linkage and impact on the viability of resource recovery materials. Consequently, the availability and stability of markets for recovered materials is expected to influence the feasibility of any option in the waste management system. Recycled or composted materials will need a substantial market for the activity to be sustainable. Otherwise these activities will always need input to keep the system running. Currently, in Malaysia efforts in the identification of markets for recovered materials is very much lacking. A simple example is in the fact that there is no policy on the procurement of recycled products in government institutions. Undoubtedly, recycled products will become more expensive as the market for these product shrinks. The supply of recovered materials to such markets must also be stable. Otherwise, the industries dependent on these recovered materials will be vary in investing in these recovered materials. Of note is that there are currently, small markets involved in utilizing recovered materials such as Malaysian Newspaper Industry (MNI), KL Glass, Malaya Glass, Alcom for aluminum cans and Genting Sanyan for recycled paper (Hendri *et al.*, 2000). Similarly, markets for compost is also lacking though the potential to utilize it in agriculture and landscaping activities in Malaysia is wide. Consequently, these markets should be further developed to ensure the feasibility of the recycling and composting option in waste treatment and resource recovery.

4.2.5 Issues and Trends in Solid Waste Disposal

1. Land Matters

The availability of land for final disposal is increasingly becoming difficult as the country becomes more urbanized. Currently, almost 97% of Malaysian waste is disposed in landfills but a major problem in Malaysia is the allocation of land for solid waste disposal. Most municipalities are finding it difficult and costly to allocate or acquire land for solid waste disposal. Existing landfills are quickly becoming full as waste generation continues to increase. This is especially true for urban centers such as Kuala Lumpur where the land is scarce and the cost of disposal is high. The other problems associated with acquiring land for disposal is the increasing NIMBY (Not in my Backyard) attitude of the public. Furthermore, under recent regulation in Malaysia, the allocation and construction of landfills come under the requirement of an EIA and other various standards. This increases the cost of such areas leading to overloading of existing dumping grounds or illegal disposal of waste. The other issue related to land matters is the allocation of such land in the existing land use planning framework. Allocation of land for solid waste disposal is a sensitive matter in the Structure and Local plans since such documents are legally binding and are open for public review. This indirectly reduces the value of the surrounding land of these proposed landfills. Consequently, land matters as well as solid waste management comes under the purview of the State government. As such the allocation and management of these lands come under the State. However, it is anticipated that in the event that the responsibility of solid waste management is transferred to the Federal government under the proposed Solid Waste Act, then there might arise sensitive issues for the allocation of landfills. This is because then these landfills will come under the purview of the Federal government.

2. Land Contamination

One issue that is anticipated to become increasingly important is the issue of land contamination from land being used as solid waste dumpsites. Contaminated land refers to land, which has been environmentally polluted due to its usage and as such, may cause detrimental impacts to future residents. Contaminated land includes previously used land for industrial areas as well as areas used as dumpsites. These unsanitary landfills have the potential to pollute the soil and groundwater as well as cause land subsidence and toxic gas emissions. Currently it is anticipated that there are more than 230 such sites in Malaysia and countless more open dumps which have been forgotten which will come under the context of land contamination. Some of this land has been developed for commercial and residential use, which may pose hazards to these residents. The subject of land contamination is a very big issue in the USA and other developed countries due to experiences such as the Love Canal. Consequently, stringent legislation has been developed to rehabilitate these contaminated lands with legislation such as the Superfund in the USA. The problem of contaminated land in Malaysia is still relatively unknown and as such has largely gone unnoticed. However there has been recent interest in this subject due to the effects of globalization since many of the multinational countries that operate in Malaysia follow their international policy on contaminated land when dealing with land transactions in Malaysia (Balamurugan and Dennis, 1999). A national conference on contaminated land touching on matters of solid waste dumping ground in Malaysia has been planned in 2001. Consequently, the rehabilitation of land used for solid waste disposal is expected to become a national issue in the future.

3. Hazardous Household Waste

Currently, the management of hazardous waste in Malaysia comes under the purview of the EQA, 1974 under the category of Scheduled Wastes. However, certain hazardous waste generated by households does not come under this legislation. This refers to lead, cadmium and mercury contents in household waste such as lead-acid batteries, nickel-cadmium batteries used in hand-phones, mercury in electric lighting as well as leaded glass used in television picture tubes. The presence of these materials in the waste stream presents toxicity pollution problem to the landfills, which in turn may turn up in the leachate and groundwater. Most developed countries are beginning to address this problem by requiring manufactures to reduce the content of this items in the consumer product or to take back this items and dispose of them properly (McCarthy, 1994). In Malaysia this issue needs to be tackled early during the legislative formulation process possibly providing legal definitions and management responsibility of the private waste managers.

4.3 Derived Key Issues of Solid Waste Management in Malaysia

Based on the functional issues of solid waste management in Malaysia, five key issues have been derived that will need to be addressed in the policy framework for Integrated Solid Waste Management in Malaysia. These five key issues are :-

I. Strategic Planning and Legislative Reforms in Solid Waste Management

II. Integrative Aspects in Solid Waste Management

III. Economic Factors in Solid Waste Management

IV. Stakeholder Attitude & Awareness in Solid Waste Management

V. Research Needs in Solid Waste Management

4.3.1 Strategic Planning & Legislative Reforms in Solid Waste Management

International trends reveal that strategic planning and legislation in solid waste management plays an important role in waste generation, waste management options and the effectiveness of the entire solid waste management framework. Many of these countries have adopted strategic planning by developing policies and strategies that contain targets and measures to address the solid waste management issue. Furthermore, the use of legislation suited to country specific conditions has been identified as one of the most important instrument for transforming policies into action (UN, 1992). However, in Malaysia this has been a very slow process though the country is gearing to achieve developed status by 2020. Consequently, only recently is Malaysia considering a Solid Waste Act that is still in the draft stage. Furthermore, there are no formal policies or strategies to address the issue of solid waste management on a national level (Table 4-16). This need for policies and legislation have been identified as a serious need in Malaysia to address its solid waste management issues (Zalina, 2000).

Table 4-16 : Development of Solid Waste Legislation & Strategy

Country	Legislation/Strategy
EU	▪ Waste Framework Directive 1991 ▪ Packaging Waste Directive 1994 ▪ Landfill Directive 1999
UK	▪ Making Waste Work 1995 ▪ Landfill Tax 1996 ▪ Waste Strategy 2000
USA	▪ Resource Conservation & Recovery Act 1976 ▪ Comprehensive environmental Response, Compensation and Liability Act 1980 ▪ Various State Legislation
Sweden	▪ Environmental Code 1999
Spain	▪ Packaging Waste Law 1997 ▪ Waste Law 1998
Israel	▪ Recycling Law 1998
China	▪ Solid Waste Law 1995
Malaysia	▪ **Proposed Solid Waste Act**

4.3.2 Integrative Aspects in Solid Waste Management

Integration in solid waste management refers to the fact that decisions on solid waste management must be done taking into consideration the economic, environmental and social aspects. It also refers to the fact that all stakeholders in the solid waste management are considered prior to making decisions realizing that all the systems in the waste management process are inter-linked and affect each other. Consequently, integration in solid waste management means that there will be trade-off between the various aspects of the system and stakeholders. Therefore Integrated Solid Waste Management takes on a holistic approach and manages the waste in an environmentally, economically and socially sustainable manner as well as involves the use of an optimum combination of treatments. Contrary to popular belief that environmental issues are more important than social and economic issues, the reality in the priority for sustainable waste management has generally been :- 1) Economic viability, 2) Social pressure and 3) Environmental benefits Consequently, environmental benefits cannot be incorporated into the waste management system unless that system is economically and socially acceptable. Thus resulting in the need for integration of all these aspects (McDougall, 1999). In Malaysia, the integrative aspect is believed to be largely lacking. Integration in Malaysia is needed in the decision making process on solid waste management, in addressing the needs and responsibilities of the various stakeholders and in incorporating solid waste management in issues in other government policies. Integration here for Malaysia does not mean that all stakeholders or options are given equal value. Integration means that all these factor are considered and addressed in a way that results in effective and locally suitable solid waste management framework.

4.3.3 Economic Factor in Solid Waste Management

The economic factor in solid waste management can be clearly seen in the close correlation between economic growth and solid waste generation. Increased standard of living is linked with increase in waste production due to consumption activities. Furthermore, international trends also indicate that economic policy instruments are increasingly being used for solid waste management. It is argued that market instrument based on economics will achieve a more efficient management of solid waste than a policy based solely on legislation (Bailey, 2000). Furthermore, such instruments may provide the incentives for encouraging trends that are conducive for proper solid waste management (Turner *et al.*, 1998).

Consequently, international trends have revealed an increasing use of economic policy instruments complementing traditional environmental policy instruments based in regulation. Notably are the use of taxes on the producers of packaging materials to reduce packaging waste and increasing the use of recycled products (Zoboli, 1994). Furthermore, the need to develop market for the recovered materials has also been source of deep concern in many of these countries. Without this economic factor being considered in the waste management system, recycling and composting will invariably be unsustainable as prices fluctuate and recovered material demand is unstable (McCarthy, 1994). Furthermore industries themselves generally function on economic principles where the concept of profit driven is prevalent. This results in industries designing packaging for product differentiation thus resulting in increased sales which in turn amplifies the problem of packaging waste (Curzio, 1994).

Consequently, it is believed that Malaysia has still not grasped the significance of the economic factor in solid waste management. There are currently minimal solid waste management practices implemented on economic instruments except probably for scavenging and recycling which is economic driven. The majority of the cost for waste management is still borne by the government while industries have still not contributed significantly to being responsible for the waste they produce. The actual cost is probably transferred to the environment by increasing waste disposal in unsanitary sites causing pollution. Producers continue to produce increased packaging materials with minimal concern for the recyclability of these products and their impact to the total waste generation problem. Consequently, the economic factor in solid waste management must be considered to ensure that it complements other policy instrument such as legislation and public awareness.

4.3.4 Stakeholder Attitude & Awareness in Solid Waste Management

The choices and behaviors of stakeholders probably represent one of the most critical variable in solid waste management. This refers to public and the industrial sector's attitude in solid waste management where they decide on what and how much to buy and use or produce. This ultimately also results in how much of waste is produced (Curzio, 1994). Furthermore, stakeholders (public or other stakeholders) attitude also decides on how these wastes are going to be treated, recovered or disposed. Consequently, it is generally recognized that public attitude is essential for the success of a solid waste management system (McDougall, 1999). However, it must also be recognized that sometimes that what the public says and what it actually does could be entirely different (Warmer, 1999d).

In Malaysia it is believed that there is a need for greater emphasis on increasing stakeholder awareness especially the public on sustainable waste management (Irra and Agamuthu, 1999). There is also a big gap between what the Malaysian public wants and what it is willing to do or pay in terms of solid waste management (Brunner and Zitawi, 2000). Consequently, this has been advocated as an important area for policy instrument to concentrate on in solid waste management (Irra, 1999). The other aspect of stakeholder attitude relates to the industrial sector and their interest and awareness in solid waste management. The issue here could be due to either one of two factors. The first is the fact that the industrial sector desires to participate in improving solid waste management through recycling and the use of resource recovered products but are lacking the information, technical and financial resources to move into this direction. The second is the fact that the industrial sector does not want to participate in solid waste management possibly due to perceiving it as an additional cost to their business. Both these issues may exist but regardless of the reasons, the participation of the industrial sector is very important as a first step in tackling the solid waste management problem

4.3.5 Research Needs in Solid Waste Management

The final key issue in solid waste management concerns the need for research in this area. Research is probably the fundamental factor that supports all other aspects of solid waste management. The lack of data and research even on the most basic information of solid waste management in Malaysia makes proper decision making regarding solid waste management ineffective. Consequently, research in this area is needed to set realistic goals in the National Strategy, help decide on the suitability of certain policy instruments and finally to formulate innovative solutions to the waste management problem.