

A REVIEW OF MUNICIPAL SOLID WASTE MANAGEMENT IN MALAYSIA

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Abstract. The tremendous increased of municipal solid waste (MSW) generation in most major cities in Malaysia is observed as a main issue recently. This paper reviews the MSW management comprises many issues arises from the past two decades till the present scenario. It briefly discussed the latest definition of the solid waste based on the Solid Waste and Public Cleaning Management Act (Bill 2007). Out of many MSW discussions, this paper also covers the recent status of the MSW generation, the regulations, the trends of MSW generation as well as local research effort which could a wide interest to the researchers and practitioners. It is hoped that this work will provide a ready reference as additional databases on MSW management situation in Malaysia. Thus an appropriate action can be taken by the relevant authority for their future planning and decision-making purposes.

Keywords: Disposal systems; Malaysia; municipal solid waste (MSW) management

1.0 INTRODUCTION

Malaysia as one of the developing country in South-East Asia with the population of 28.45 million inhabitants in 2010 [1] faces escalating municipal solid waste (MSW) management and disposal problem. Despite concerted efforts to promote Recycling, Reduction and Reuse of materials (3Rs) through the National Campaign on Recycling, the amount of solid waste recycled remained at less than

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5% of the total waste disposed [2]. Due to the increase in the amount of MSW generation yearly, more landfills are needed and the Malaysian government had allotted two more sanitary landfills at Seelong in Johor and Bukit Tagar in Selangor to fulfill and implement the future requirements of the Ninth Malaysia Plan (2006 - 2010).

In Peninsular Malaysia, the total quantity of MSW generated has increased from 19,100 tonnes per day in 2005 to 21,100 tonnes per day in 2010 [2] or an average of 1.1 kilogram per capita per day, a growth parallel with the urban areas in many other Asian countries. The government and local authorities should play a more proactive role in planning to counter the problem mentioned above before it poses a more serious threat to the environment in the near future.

In most Malaysian municipalities, the most common practice of MSW disposal is open dumping [3 - 4] which lack any precautionary environmental and health measures. This method is also the easiest and comparatively cheaper method for removing waste from the immediate environment. The open dumps or dumpsites can cause degradation to the environment since they are susceptible to open burning, groundwater pollution and exposed to scavengers and disease vectors [5]. For example, in 2004, a total of 208 open burning cases were detected in disposal sites and this amount increased significantly to 367 cases in 2005 or in average 8.25% [6 - 7]. In 1998, there were 230 waste disposal sites recorded and more than 78% or 181 sites practiced open dumping, while the remaining 49 sites were uncontrolled landfilling. However, the volume of disposal sites decreased slightly to 161 in 2002, where only 77 sites or 47.8% still practiced open dumping and the rest of the 84 sites are landfill with control tipping [8 - 9]. Due to the rapid increase in the nationwide land cost, awareness pertaining to environmental pollution, opposition from the surrounding residential/communities and others, the decision to upgrade some of the existing landfills are seen as improvement measures embarked by the government during the Ninth Malaysia Plan implementation.

Presently, the available landfill volume is limited and more than half of existing landfills are nearly reaching the maximum capacity in receiving the MSW disposal [9]. The environmental pollution, leachate problems, disturbing odour, and opposition by the surrounding residential community are other challenges faced by the government before considering to open any landfills site. Moreover, the poor site design, inadequate compaction, lack of leachate collection as well as treatment system and shortage of landfill covering are amongst the common

problems experienced in most of the developing countries including Malaysia. These problems occur due to almost 90% of all landfills functioning as non-engineered open dumping disposal facilities [10]. This situation will create a considerable health and environmental problem if the potential adverse impacts are not monitored carefully.

In Malaysia, the intensive effort to compile a comprehensive MSW database is relatively new. Thus, local researchers only investigated certain aspects pertaining to the issue. For example management issues [11 - 13], restructuring of the municipal organisation [14] and waste generation rate [15]. Other researchers also concentrated more on the comparison of compiled landfill information between Malaysia and Japan [3], correlation between amount of MSW generation and population increase [16], contribution of production structure towards the change in the types of MSW compositions [17], and the amount of solid waste recycled [2].

In this paper, the definition of MSW is briefly elaborated in Section 2, followed by the trends of MSW disposal in Malaysia. In Section 4, the discussion focuses on the related MSW regulations, while Section 5 discusses the status of MSW disposal practiced in Malaysia. Section 6 focuses on the existing MSW databases in Malaysia. Lastly, the discussion and conclusions are provided in Section 7.

2.0 DEFINITION OF MUNICIPAL SOLID WASTE

MSW is garbage generated by household and commercial sources, that is collected and either incinerated, recycled or disposed in the MSW landfills [18]. MSW includes the solids discarded by the end consumers, i.e. residential, commercial, institutional, industrial and municipal sources. It can be divided into several categories, including food wastes, yard waste, containers and packaging, durable goods (e.g., appliances) non-durable goods (e.g., newspaper, office paper), and miscellaneous inorganic wastes. The example of the MSW generated from each major source is shown in Table 1.

For many decades in the past, there was no clear or specific definition for solid waste and solid waste management in Malaysia [15]. The specific legislation on Solid Waste and Public Cleaning Management were amendment in 1971 and

revised in 2007. According to the Solid Waste and Public Cleaning Management Act (Bill 2007), the definition of solid waste ([19]; pp. 12) includes:

- i. any scrap material or other unwanted surplus substance or rejected products arising from the application of any process,
- ii. any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled, or
- iii. any other material that according to this act or any other written law, is required by the authority to be disposed of.

Table 1 MSW generation as a function of sources

Sources	Type of waste generated
Residential (single-and multi-family homes)	Food scraps, food packaging, cans, bottles, newspapers, clothing, yard waste, old appliances.
Commercial (office buildings, retail companies, restaurants)	Office paper, corrugated boxes, food waste, disposable tableware, paper napkins, yard waste, wood pallets.
Institutional (school, hospitals, prisons)	Office paper, corrugated boxes, cafeteria waste, restroom wastes, classroom wastes, yard waste.
Industrial (packaging and administrative; not process wastes)	Office paper, corrugated boxes, wood pallets, cafeteria wastes
Municipal	Litter, street sweepings, abandoned automobiles, some construction and demolition debris.

Source: Pichtel [44; pp. 6]

However, the Environmental Protection Agency (EPA) definition for MSW is given as follows:

“MSW otherwise known as trash or garbage that consist of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspaper, appliances, and batteries. Not included are materials that may also be disposed in landfills, but are not generally considered MSW, such as construction and demolition debris, municipal wastewater treatment sledges, and non hazardous industrial wastes.”

Source: US EPA [20]

Although, the MSW definition varies in certain view point, it generally focuses around the same domain of definition.

3.0 TRENDS OF MUNICIPAL SOLID WASTE GENERATION

The trends of MSW generation in Malaysia have been studied since the early 1980s. On average, the MSW generation increased 2% annually [21] and is expected to increase up to 2.5 - 3% due to rapid population and economic growth during the Ninth Malaysia Plan (2006 - 2010). Based on the census data and Malaysian experience in waste study, Sekarajasekaran [22] projected the residential waste generated in 20 studied municipalities would increase almost 100% from 1980 to 1990 due to growing urbanisation. This projection is realistic, where the total MSW generation in Malaysia increased from 5.91 million tonnes in 2001 to 6.97 million tonnes in 2005. Moreover, the average per capita generation rate increased from 0.67 kg/capita/day in 2001 to 0.8 kg/capita/day in 2005 [2] and this amount is expected to increase to double digits in line with the population growth by the year 2020. The details of MSW generation in Peninsular Malaysia according to states are shown in Table 2. This clearly indicates that the quantity of MSW generation in Malaysia is increasing with time, pointing to a need for a more efficient management system and disposal alternative of MSW in the near future.

Generally, the solid waste composition in most Asian countries is highly biodegradable with high moisture contents such as food waste, paper, plastic/foam, agriculture waste, rubber/leather, wood, metal, glass and textiles [23]. In Malaysia, the average components of MSW are quite similar with the largest categories consisting of food waste (45%), plastic (24%) followed by paper (7%), iron (6%) and lastly 3% for glass and others [2]. Therefore, continuous effort is required to identify a prudent management approach to reduce the burden of existing MSW disposal systems (i.e., open dumping and landfilling).

Table 2 Solid waste generation in Peninsular Malaysia by states (in '000 tonnes)

States	1996	1997	1998	1999	2000	2010 ¹	Average growth rate (1998 -2000, in %)
Kuala Lumpur	n.a.	n.a.	1,058	1,070	1082	1205	1.14
Selangor	n.a.	n.a.	1,169	1,204	1240	1617	3.04
Pahang	n.a.	n.a.	202	206	210	252	1.98
Kelantan	n.a.	n.a.	123	126	120	120	-1.22
Terengganu	n.a.	n.a.	119	122	125	157	2.52
Negeri Sembilan	245	250	267	278	291	427	4.69
Melaka	192	200	208	216	225	322	4.30
Johor	854	890	927	956	1005	1456	4.49
Perlis	26	27	28	28	29	34	1.79
Kedah	507	538	569	569	631	977	5.49
Pulau Pinang	570	591	611	611	648	844	3.03
Perak	672	696	719	719	763	996	3.06
Total	3066	3192	6,000	6,137	6378	8407	2.86

Note: n.a. ~ not available;

¹estimated only based on the average growth rate (1998 - 2000) for each state except for Kelantan

Source: Government of Malaysia [2]

4.0 SOLID WASTE MANAGEMENT REGULATIONS

In late the 1960s and early 1970s, Malaysia faced a tremendous increase in MSW generation and lacked in disposal sites [24]. As a response to this situation, the Local Authorities (LAs) took further actions to constitute some regulations related to waste management at the three tiers of government structure namely federal, state and local throughout the country. At the federal level, the MSW matters are under the purview of Ministry of Housing and Local Government (MOHLG), while the state government is responsible to guide and assist the LAs in strengthening their institution and financial capabilities for MSW management [25]. The Local Government Act, 1976, on the management of solid waste and maintaining cleanliness of town and cities are under the LA.

The three existing legislations adopted which are directly related to solid waste management in Malaysia [25 - 26] are:

- i. Environmental Quality Act - This act was enacted in 1974 for the prevention, abatement and control of environmental pollution and enhances the general quality of the environment.
- ii. Local Government Quality Act - The act was adopted in 1976 and provided better legal and institutional framework for LAs to carry out their duty. The act provides power to LAs to maintain deadlines in towns and put up sanitary services for the removal of waste in their respective operational areas. It also prohibits the deposition of waste in any channel, stream, drain and river. LAs are empowered to enact the by-laws to assist them in carrying out their duty under this act, such as the Uniform Building by-Laws.
- iii. Town and Country Planning Act - This act was enacted in 1976 for proper control and regulation of town and country planning and development in LA areas. It provides for the local planning authority, whose function is to prepare draft structure plans and spells out measures for improvement of the physical environment and connections.

Thus, the existing legislations related to solid waste management are seen to be having so many obstacles as well as disadvantages to manage the MSW generation in a holistic manner in order to reach the goal of an integrated sustainable waste management.

To address the above situations, the legislation of the Solid Waste and Public Cleansing Management Act 2007 was adopted to facilitate and coordinate the implementation of the strategies and to measure the National Strategic Plan for solid waste management. It also established the National Solid Waste and Public Cleansing Management Corporation and amended three other legislations to ensure that there is concerted effort in solid waste management. The strategy also included to ensure that the newly established Department of Solid Waste Management will focus its energy, effort and human resources on the formulation of policies, strategies, plan of action as well as legislation without being held down with the day-to-day running of the solid waste management. The day-to-day running is left to the corporation which takes the role of the local authorities with the legal power to enforce the law and carry out the monitoring and enforcement activities.

In this context, the federal government has also taken out all those provisions pertaining to solid waste management from the Local Government Act, 1976 and the Street, Drainage and Building Act 1974 to ensure that there is no overlapping

of jurisdiction and provides clear and coordinated approach for the various agencies while carrying out their respective role and responsibilities. Moreover, the legislation also added a provision to the Town and Country Planning Act 1976 to ensure that, when a local planning authority deals with an application for planning permission, it will take into consideration the provisions of the Solid Waste and Public Cleansing Management Act, 2007. Thus, the recent development exhibits positive efforts taken by the government towards a holistic approach in the future planning of physical development to sustain the MSW management [27]. Since the legislation is still newly enacted, the efficiency of such implementation cannot be measured instantly.

5.0 MUNICIPAL SOLID WASTE DISPOSAL SYSTEMS IN MALAYSIA

There are four primary methods for handling the MSW practices worldwide, namely i) open dumping and landfilling, ii) incineration, iii) composting, and iv) recycling.

Open dumping and landfilling are the most common method for disposal of MSW in Malaysia. Open dumping is still observed in mostly all municipalities, where the waste is dumped in an uncontrolled manner, and can be detrimental to the environment. This primitive stage of waste disposal is practiced by about three-fourths of the countries and territories in the world [28]. This method is not a traditional but it is the most cost effective method in this country for many years, even though in certain areas, other options may not be as cost effective [29].

Alternatively, the sanitary landfills have been widely recognised as effective means for disposal of MSW worldwide. This modern method is quite new in the local scenario, but in the United States (US), it has been practiced as the primary method since 1959 [30]. Sanitary landfill is an engineered solid waste disposal method on land, in a manner that protects the environment. It spreads the waste in thin layers, compacting it to smallest practical volume, and covers it with compacted soil by the end of each working day or at more frequent intervals if necessary [31]. By using this disposal method, the landfill constitution and management can be sufficiently developed to ensure that even large volumes of such materials can be handled and disposed in a way to protect public health and minimise adverse impacts on the environment [32 - 33]. Due to the reason of

sanitary landfill being ‘more environmentally friendly’, in the Seventh Malaysia Plan, the government has taken further actions to spend RM20.9 million to build 9 sanitary landfills and upgraded the 27 existing landfills in 34 LAs [34]. Although the operation and design were substantially improved as compared to the earlier land disposal efforts, it still suffered from numerous deficiencies such as groundwater contaminators, surface run off, odour and gas emission, and related public health concerns.

The second, incineration is controlled burning of solid, liquid or gaseous waste. This disposal method is widely practiced in the European Union (EU) countries as a volume reduction technique since the 1890s. For example, in 1998, the total waste incinerated in Europe was estimated around 40 million tonnes a year and the amount was expected to increase to 62 million tonnes in 2006 [35]. The systems used can be divided into two broad categories; i) mass burning technology of substantially unprocessed refuse, and ii) “refuse-derived fuel” (RDF) where a prepared refuse-based fuel is burned. The modern incineration system uses high temperatures, controlled air, and excellent mixing to change the chemical, physical, and biological character or composting of waste materials [36]. There are three major benefits could be gained from the incineration process; i) the burning process can reduce almost 70 percent of raw waste volume, with the ultimate result of extending the lifetime of a land disposal facility, ii) the waste to energy technology system can be beneficial in terms of the recovery of heat energy from combustion for electricity generation. Lastly, the incineration process can also act as a detoxification mechanism whereby the destruction of microbial and other pathogenic organisms occur within the bulk waste.

The third, composting is a process that involves the biological decomposition of the organic matter, under controlled operation to produce a humus-like stable product. It involves the aerobic digestion of the biodegradable fraction of MSW, such as paper and cardboard, food and garden waste. Since the aerobic microorganisms’ activity is fundamental in the composting process, it extracts energy from the organic matters through a series of exothermic reactions that break the material down to simpler materials. The basic composting process is given as following equation:



For a proper function of a composting operation, a pre-requisite is needed, i.e. removal of non-compostibles such as metals, glassware and ceramic items. The success level of the process also depends on the moisture content in the MSW materials. If the mixture is too dry, the microorganisms cannot survive, and the composting stops. If there is too much water, the oxygen from the air is not able to penetrate to where the microorganisms are, and the mixture becomes anaerobic [37]. Besides that, temperature about 15°F range will destroy pathogenic bacteria. The fourth, recycling refers to the collection and separation of waste and their subsequent transformation or remanufacturing into usable or marketable materials. It was traditionally seen as 'an environmentally friendly' disposal method which might also induce a change in wasteful consumption patterns. Usually, recycling ranks as the second best alternative in waste management hierarchy after 'reduce the waste' effort. It diverts potentially large volumes of materials from landfills, as well as combustors, and prevents the unnecessary waste of natural resources and raw materials [18]. The key aspect of successful recycling activities depends on the integrated participation and involvement from various parties such as households, surrounding communities, etc. Previous studies have proved that the percentage of waste recycled can be raised by increasing the participating rate of households in recycling programmes and by increasing the number of waste items that can be reused, such as plastic, paper, glass, and aluminum. The advantages of using recyclable materials are that there is reduced use of virgin materials with consequent environmental benefits in terms of energy saving in the production processes, reduced emissions to air, water, and onto land. In most cases, the emissions from the recycling process for paper are less than that from the production of recycled products; for example the recycling of glass produces higher solid waste emissions than the production of virgin glass [38].

As discussed in the above four disposal systems, landfills still cover 60 to 90 percent of the served areas, and are projected to cover more than 75 percent in the near future, with 80 percent of the waste disposal sites having less than 2 years of remaining operating life [39]. Thus there is emphasis on the urgency for municipalities to secure new landfills is a priority, before the existing ones are exhausted. Moreover, the technical evaluation study in 1992 also found that landfills would remain the major waste disposal system for the nation in the near future. Landfilling is done almost solely and open dumping is being practiced and takes place at about 50 percent of total landfills [34]. The landfills sites can be categorised into five types according to the landfill stages [9,40] such as, i) open

dumping sites, ii) open tipping site, iii) landfill with bund and waste disposal covered with layer of suitable cover materials, iv) landfill equipped with pipe system for leachate recirculation and aeration, and v) sanitary landfill. There are 161 landfill sites available across Malaysia and only 6 landfills or 3.7% are sanitary landfills while the remaining 77 landfills still practice open dumping [41]. With regards to this problem, the government has planned to close and rehabilitate the existing 112 unsanitary landfills across the nation and upgrade some of the existing landfill sites to sanitary landfills, build integrated material recovery facilities, sanitary landfills and transfer stations during the Tenth Malaysia Plan (2011 - 2015) [27]. These efforts are seen as steps taken by the government to reach towards sustainable solid waste management in Malaysia, for short and the middle term duration.

In the Seventh Malaysia Plan (1996 - 2000), the government had purchased seven mini-incinerators with the capacity of 5 to 20/tonnes/day to operate in the resort Islands in Labuan, Tioman, Pangkor and Langkawi with a estimated cost of RM17 million [42]. Due to scarcity of land and high MSW generation rate especially in the central region of Peninsular Malaysia, the government has planned to install three bigger capacity incinerator plants in Kuala Lumpur, Selangor and Pahang.

The government is presently looking at composting and recycling activities as alternate waste disposal methods for the future. Recent studies revealed that, less than 5% of the total waste (almost 10000 tonnes/day) is actually separated and recycled, although a large amount of waste has the potential to be recycled [43]. The government has also taken further initiative to relaunch the recycling campaign on 2 December 2000 with a target of 22% waste to be recycled by year 2020.

6.0 MUNICIPAL SOLID WASTE DATABASES

The number of current available information and/or databases on solid waste management in Malaysia is quite limited. For many decades, until the end of 1987, there was no nationwide systematic analysis and periodic documentation from any local authorities to record waste generation rate, which has resulted in inaccurate and outdated databases [43]. The first nationwide compilation of waste generation and composition was carried out by the MOHLG only in May 1987. Since then,

the second study was conducted by the Malaysian Industry-Government Group for High Technology (MIGHT) in May 1994, followed by another state selected survey on November in the same year. The coverage of this survey was limited to the Kuala Lumpur Federal Territory, the states of Selangor, Melaka, Negeri Sembilan and Johor. On the other hand, the first written report on solid waste management by a non-governmental organisation (NGO) was published in 1978. The Environmental Protection Society of Malaysia (EPSM), as a local NGO carried out the survey in five municipalities in Klang Valley [14]. The findings of the survey show that there were three major inadequacies in solid waste management including improper disposal manner, insufficient coverage of the collection systems and inefficient collection methods.

Recent studies also indicate that it is very difficult to obtain useful and comprehensive information/data-base related to MSW management in most developing countries as compared to the developed country. For example, Table 3 shows the compilation of landfill information for Malaysia (as a developing country) compared to a developed country such as Japan [3]. As seen in the table, some information gap are present in the Malaysian column such as incomplete or unavailable information causing problem for future planning and improvement purposes.

7.0 DISCUSSION AND CONCLUSION

Since early 1980s, MSW management issues emerged in Malaysia due to increasing amounts of solid waste generated, rising disposal costs, shirking landfill capacity, uncontrolled illegal open dumping, and strong opposition to the sitting of new solid waste facilities. It occurred due to dramatic changes in life style, increase in population growth, urbanisation, economic growth and raise in the urban household income. The government or local authorities are finding themselves dealing with more complicated and diversified issues regarding MSW management, particularly disposal system alternatives, most of which are difficult to quantify.

However, recent development indicates that the Malaysian government gives priority to MSW management and related sanitary efforts. In the Tenth Malaysia Plan (2011 - 2015), a National Strategic Plan will be implemented with emphasis on the upgrading of unsanitary landfills as well as the construction of new sanitary

landfills and transfer stations with integrated material-recovery facilities. The new legislation to streamline solid waste management was enacted on September 2007, specifically to facilitate the implementation of the strategies and to measures properly [19]. In addition, the awareness campaigns and related activities will be increasingly organised to educate the public on the benefits of practicing sustainable consumption. Lastly, the establishing of the solid waste and public cleansing management corporation becomes a platform to implement and administer solid waste policy, planning and management in a holistic manner.

Table 3 Comparison of compilation landfill information between Malaysia and Japan

	Malaysia	Japan
Waste generation	More than 6 million tonnes/year MSW	General waste 52 million tonnes. Industrial waste 400 million tonnes (2001)
Collection rate	70 %	100 %
Waste recycled	Unknown	General waste 15%. Industrial waste 45.8 %
Landfill-related legislation	The refuse collection, removal and disposal (Federal Territory) Act (1981). EIA is necessary after 1989	Waste Disposal an Public Cleansing Law (1971). Technical guideline issued in 1977, and revised in 1988. Disposal standards and standards for structure and maintenance of landfills issued in 1977. In 2000, performance-based guidelines for landfills were introduced
Landfill classification	Levels 1 - 4	i. Strictly controlled landfills (for hazardous waste) ii. Controlled landfills (for nonhazardous municipal and industrial wastes) iii. Inert waste landfills
Total number of landfills/dumps	161 active landfills (2002). Most have a remaining capacity of less than 2 years	4794 active landfills (2004)
Sanitary (controlled landfills)	Unknown	Active “controlled landfills” in 2004: 3151 (total) i. Industrial waste landfills: 1074 (strictly controlled landfills: 41) (controlled landfills: 1033) ii. General waste landfills: 2077. Also 1643 active “inert waste landfills” exist for industrial and C&D wastes
Open dumps	60 % open dumps, managed poorly, high leachate production due to high precipitation	Operating open dumps do not exist at present; 538 improper old landfills requiring remedial actions

Source: Inanc *et al.* [3]

In spite of having research done in specific problems related to the MSW management in Malaysia, the compilation of local MSW databases has not been recorded thoroughly. This is extremely important and requires urgent attention by the related authority as recent development indicates that a comprehensive database with latest information is crucial especially in the central area of Peninsular Malaysia.

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