Health Risk Associated with Management of Municipal Solid Wastes in Malaysia

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ABSTRACT

The development in urban and industrial sectors in Malaysia has a rapid growth during the last two decades. These developments are associated with the increase of municipal solid wastes (MSW) generated from human activities. The quantities of MSW in Malaysia are estimated to be 27,284 tonnes per day, and more than 35% of these wastes are food wastes. The environmental conditions in the country, which include humidity and temperature, play an important role in the increasing concerns of health risks associated with these wastes. The organic matter in MSW is more degradable than plastic solid waste. However, it is more suitable as a medium for the reproduction and distribution of infectious pathogens. Thus, the adverse effects on the public health level due to poor disposal represent one of the limitations on the plan that is carried out by the country to become a developed country by 2020. Hence, Malaysia has adopted stringent regulations for the management of solid wastes since 1974. Recently, the segregation of solid wastes at the source point is applied in several public centres and at household level. The limitation does not only include the management, but it is extended to include the disposal method, which is conducted using open incineration with several disadvantages. However, there is no plan to use the alternative treatment systems in Malaysia. The trend would be moving towards the advanced incinerators to minimise national carbon dioxide emission. This paper discusses the current status of management and treatment of solid wastes, as well as the future of the alternative technologies for inclinators in Malaysia.

Key words: municipal solid wastes, health risk, management, Malaysia

1. INTRODUCTION

The development in urban and industrial sectors in Malaysia has a rapid growth rate during the last two decades. In the urbanisation sector, the increase of communities and cities has led to the increased quantity of municipal solid wastes (MSW) generated from houses and public facilities accordingly. In Malaysia, the Population Equivalent (PE) has increased by 27.8% during the period from 1997 to 2012. In contrast, the industrial sector has increased from 38.5% in 1980 to 44.5% in 2002. These developments have contributed in increasing

the gross domestic product (GDP) from 19.64% in the 1980s to 31.56% in 2004 [1]. The electrical and electronics manufacturing sector has enhanced the Malaysian economic by more than 60% during the period from 1991 to 1996 [2]. However, these developments are associated with the increase of MSW generated from human activities. MSW represents one of the limitations on the plan that is carried out by the country to become a developed country by 2020. Therefore, the country has adopted stringent regulations for the management of solid wastes since 1974. These regulations are described in more detail in a new version of Environmental Quality (Scheduled Wastes) Regulations (2005), and include collection, segregation, storage, transportation process, treatment, and the final disposal into the environment.

Municipal solid waste (MSW) is a general term that includes the non-hazardous solid waste from households, industrial, commercial, and institutional establishments (including hospitals), market waste, yard waste, and street sweepings. Meanwhile, municipal solid waste management (MSWM) refers to the collection, transportation, treatment, recycling, and the disposal processes of MSW [3]. The main goal of MSWM is to protect environmental health and support the efficiency and productivity of the economy [4]. Therefore, the improper management of MSW affects human health. For example, open dumping in most unsanitary landfills loaded with 50% of food waste may contaminate the land and air, and then contribute in the distribution of diseases around the near populated area. In some cases, open incineration is applied; nonetheless, incineration is not a suitable technology for the treatment of solid wastes due to the inevitable production of hazardous pollutants, including dioxins and furans [5]; [6]. This provides a strong support for a move away from costly destruction of solid wastes by incineration. The other limitation of incineration is climate change or global warming, where incineration leads to the production of carbon monoxide, nitrogen dioxide, hydrogen chloride, sulphur dioxide, chlorinated hydrocarbons, polycyclic aromatic hydrocarbons, dioxin, and furan into the atmosphere, which further contribute to the increase Earth's temperature [7]; [5]; [6]; [8]; [9]. In Malaysia, the climate temperature has increased at least 1˚C during the period from 1992 to 2013 [10] due to the increase of industrial activities. Recently, a few studies have been carried out to obtain an alternative method for treating solid wastes [11]. However, there is no plan to use the alternative treatment systems in Malaysia. The trend would be moving towards advanced incinerators that prevent the production of gases into the atmosphere, and thus, reduce national carbon dioxide emission

40% by 2020, as compared to that produced in 2005. Therefore, there is a need to device a proper disposal system of the large amount of MSW generated daily and to find more effective communication ways of recycling and energy recovery methods for MSW in the future. This paper discusses the health risks associated with the current status of the management and treatment of solid wastes, as well as the future of the alternative technologies for solid waste management in Malaysia.

2. Health risks associated with municipal solid wastes

Solid waste has less organic matter than domestic waste; however, it contains a detectable amount of infectious pathogens, for instance, bacteria and fungi, which might transmit from contaminated land by vectors, such as insects, rodents or birds [12]. In this section, the potential of open disposal as a source for infectious agents is reviewed to understand the health risks associated with these wastes on human beings and the environment. The disposal of solid wastes into the environment is an essential step in the management process. In developed countries, the disposal of solid wastes is subject to strict regulations, where it has to be segregated at home, and then, the plastic and papers wastes are recycled, while the wastes that contain organic matter, such as food wastes, are managed safely to prevent any possible risk to human health [13]. In contrast, as for developing countries, open dumping is the most common method [14]; [6].

In fact, no incidence of illness caused by infectious pathogens from the discharged solid wastes have been reported. However, health risk is possible even in the absence of reports due to the ability of several pathogens to survive in landfills [15]; [16]. Nevertheless, the source of these pathogens, *Salmonella* spp., for instance, may survive in a contaminated environment over 100 days in lower moisture (10-15ºC) and for 30 days in higher moisture (20-30ºC), while faecal coliforms can survive for over 30 and 8 days respectively [17]. *Salmonella* spp. is among several pathogenic bacteria that have the ability to cause various types of disease to humans. *Salmonella* spp. in solid wastes comes from food wastes. Among the 2000 serotypes of *Salmonella* spp., two serotypes, namely *Salmonell*a, *S. typhi* and *S. paratyphi* (A, B, C), are the most dangerous to people. The high pathogenicity of *Salmonella* spp. is due to their ability to infect nearly all living vectors from insects to mammals [18]. Besides, the bacterium has the potential to resist a wide range of antibiotics.

Faecal coliforms might be less available in solid waste due to the absence of faecal pollution in these wastes. Nevertheless, they can come from the surrounding environment and

then grow with the existence of nutrients in the solid wastes. The ability of these indicators to grow and multiply in the environment has been demonstrated in Malaysia since 1998 by Byappanahalli and Fujioka (1998) [19].

The survival of pathogenic bacteria in solid wastes and landfills is affected by several factors, including temperature, moisture, sunlight, the availability of organic matter, soil pH, soil particles, the presence of toxic substances, and the influence of competitive organisms towards bacteria survival in soils [20]. The most common pathogenic bacteria in municipal solid wastes include *Clostridium perfringens, Escherichia coli, Listeria monocytogenes, Pseudomonas aeruginosa, Salmonella* spp., *Staphylococcus aureus,* and *Klebsiella* spp. Most of these pathogens originate from food wastes.

The health risks associated with the pathogenic microorganisms in solid wastes are not limited to their abundance and/or concentrations, but also on the quality of their pathogenicity. A wide range of fungi, such as *Aspergillus* spp., produce several types of toxins. The ability of fungal spores to survive in the environment has also reported in the literature. Şahil and Otag (2013) [21] indicated that *Aspergillus* spp., *Fusarium* spp., *Acremonium* spp., *Alterneria* spp., and *Cladosporium* spp. can survive for more than one year in sand at room temperature.

In general, the concerns of health risks related to solid wastes lie in the potential of these pathogens for regrowth or persistence and transferral into the food chain [22]. The microorganisms' infectivity and survival are not synonymous terms. Survival is defined as the ability of the organisms to propagate indefinitely when placed in a suitable environment [23]. Survivability is necessary for infectivity; however, bacteria can lose their infectivity and still be recovered as viable particles [24]. The ability of pathogenic organisms to survive in solid wastes requires the presence of nutrients for their growth. Table 1 illustrates the composition of solid wastes in Malaysia, in which food and organic wastes represent more than 35% of the total weight compared to only 21% in the solid wastes generated in Australia [25].

Table 1 Composition of municipal solid wastes in Malaysia

Types of waste	2003	2004	2005	2007	2010	2012
Food waste and organic	37.4	49.3	47.5	42.0	43.5	75.0
Mix plastic	18.9	9.7	ND	24.7	25.2	21
Mix paper	16.4	17.1	18.5	12.9	22.7	1
Textiles	3.4	ND	2.13	2.5	0.9	ND
Rubber/lather	1.3	ND	ND	2.5	ND	ND
Wood	3.7	ND	4.41	5.7	ND	1
Yard wastes	3.2	ND	2.72	ND	ND	ND
Ferrous	2.7	2.0	ND	5.2	2.1	ND
Glass	2.6	3.7	ND	1.8	2.6	ND
Pampers	5.1	ND	3.81	ND	ND	ND
Others	5.3	18.2	21.93	2.6	1.8	2
Total	100	100	100	100	100	100

ND (non-detected); Source: Kathirvale et al. (2003) [26], Mohammad et al. (2007) [27], Rohana and Arshad (2010) [28]; Budhiarta et al. (2012) [29]

The environmental impact of disposed wastes include the contamination of surface and groundwater through leachate, soil contamination through direct waste contact or leachate, air pollution through burning of wastes, spreading of diseases by different vectors like birds, insects, and rodents, odour in landfills, and uncontrolled release of methane by anaerobic decomposition of wastes.

3. Management of municipal solid wastes

The management of solid wastes represents a challenge for municipalities in the urban environment. According to the United Nations Environment Protection (2010), the quantity of solid wastes produced annually is estimated to be 1.7 to 1.9 billion metric tonnes. In Malaysia, the generation rate of solid wastes ranges from 0.5 – 0.8 kg to 1.7 kg/person/day in major cities of Malaysia [26]. Nazeri (2002) [30] stated that the solid waste generation in West Malaysia has increased from 16,200 tonnes per day to 19,100 tonnes per day, and accordingly, assuming a 3.6% growth by 2020, the amount is expected to be 31,000 tonnes per day. Table 2 shows the trends of solid waste generation in major residential areas in West

Malaysia from 1970 to 2006, in which there was a tremendous increase in the quantity of solid waste generation during the period at major residential areas of West Malaysia.

Table 2 Generation of municipal solid wastes in major residential areas in West Malaysia (1970 -2006) [31]

State	Municipal solid waste generated (tonnes/ day)				
	1970	**1980**	**1990**	**2002**	**2006**
Kuala Lumpur	98.9	310.5	586.0	2,754	3,100
Johor	41.1	199.6	174.8	215	242
Perak	22.5	82.7	162.2	208	232
Penang	53.4	83.0	132.2	221	249
Selangor	18.0	56.0	122.8	478	538
Terengganu	8.7	61.8	121.0	137	154
Kelantan	9.1	156.5	102.9	129.5	146
Pahang	7.1	45.0	85.3	174	196
Seremban	13.4	45.1	82.5	165	185
Malacca	14.4	29.1	46.8	562	632

The lack of an appropriate management for these wastes could lead to the increase in the contamination of soil, water, and air, as well as an increase in greenhouse gas emissions [32]. In Southeast Asian nations (ASEANs), solid waste is the most visible environmental problem due to rapid urban growth, economic development, and industrialisation since the 1980s, which results in increased generation and composition of solid waste [33].

The management of the ever-increasing volume of solid wastes has been one of the prime environmental issues in Malaysia. According to Othman (2006) [34], the local authorities in Malaysia are responsible for solid waste management services in their various areas of jurisdiction. However, over the years, due to various constraints in infrastructure, institutional setup, and financial and technical resources, this has led to the privatisation process by the Malaysian government in 1996. The collection of solid wastes is conducted without segregation in most cities of Malaysia, until recently, the government has announced the waste segregation programme on 1 September 2015, with the objective to reduce the amount of wastes disposed in landfills. The implementation has been conducted in stages

towards a stringent enforcement later this year under the Solid Waste and Public Cleansing Management Act 2007 (Act 672). Another issue in regards to waste collection is waste collection handling. Workers are not aware of the potential hazards of these wastes and are not found to take requisite protective measures. In most cases, they do not wear plastic aprons, sturdy gloves, masks, and shoes during the collection and transportation of wastes.

The solid wastes are stored using various types of bins, such as a small bin (household), medium bin (communal bin), and large bin (hauled communal). These bins are made up of metal, plastic, rubber, concrete bin, and cardboard boxes. In the case of high-rise buildings, communal bins or central containers are used [35]. The frequency of collection in Malaysia varies from daily to three times a week. Everyday collection is normally practised in city centres, commercial areas, and public areas. In a wider perspective, direct haulage from the collection point to disposal sites without any intermediate treatment is the current practice in Malaysia. In commercial areas and public areas, there are some segregation of solid wastes, especially for plastic bottles; however, these practices are not applied at the households. It has been indicated that a majority of the problems associated with the collection of solid wastes are the nuisance caused by the passage of MSW collection vehicles, the smells, the sight of landfill areas, the negative feelings from neighbouring with an MSW collection facility, the worry for potential public health risks, and the not-in-my backyard (NIMBY) syndrome, which understandably creates a negative social attitude towards MSW treatment and landfilling [36].

The municipal solid wastes in Malaysia are disposed at landfills or dumpsites, and only a small amount are disposed to incinerators. There are 155 official dumps in Malaysia (Table 3). The operational landfill has increased to 165 in 2012 across Malaysia, catering 95% of Malaysian wastes. The Department of National Solid Waste Management reported in 2012 that only eight sanitary landfills are operating, while the remaining eleven are under various constructions. However, some of the landfills are in very bad shape so much so that there is a need for improvement in the design of the landfills, site location, size, and management of the disposal sites [37].

Table 3 Types and number of disposal sites in Malaysia [38]

State	Open dumping	Controlled dumping	Sanitary landfill	Total
Johor	12	14	1	**27**
Kedah	9	5	1	**15**
Kelantan	12	2	0	**14**
Malacca	2	3	0	**5**
Negeri Sembilan	8	6	0	**14**
Pahang	7	5	3	**15**
Perak	15	11	4	**30**
Perlis	0	1	0	**1**
Penang	1	1	1	**3**
Selangor	5	15	0	**20**
Terengganu	2	8	1	**11**
Total	**73**	**71**	**11**	**155**

A majority of the solid wastes are being buried at dumps. This practice is also applied in several developing countries, such as South Africa [39], Algeria [40], and Egypt [41], whereas, developed countries have achieved remarkable success in waste recycling [42]. The Malaysian government has recently increased its campaign for public awareness on the importance of waste recycling and waste minimisation. It is estimated that only 3% of the total solid wastes (SWs) generated nationwide are being recycled [34]. In comparison, 43% of the total solid wastes in Australia are recycled [33]. However, by 2020, about 22% of the solid wastes in Malaysia are going to be recycled, 8% composted, 17% incinerated, and 53% would be disposed into the landfills.

Open dumping is less expensive and used to reduce the volume of the wastes and stop the spread of papers and plastic; as additionally, there is no other alternative method available at this reasonable cost. However, it has been reported that open dumping represents a potential infection source of public health and environmental pollution [39]; [14]. Moreover, the rapid population density limits the utilisation of landfill facility in developing countries. Suitable landfill sites are becoming more difficult to find as urban areas expand, in addition to the transportation cost [42]; [43].

4. Future direction for management of municipal solid wastes in Malaysia

The quantity and quality of solid wastes vary depending upon the living manner of each community. However, the segregation of solid wastes at the source, reuse, and recycling would enhance public health and environmental safety. Malaysia aims in 2020 to pursue an economic development in ensuring the protection of natural resources of water from contamination, as well as human and environmental health [44]. The country has adopted a strategy based on the pollution control and preventions through the enforcement of the Environmental Quality Act (EQA), 1974. The country has planned to construct new treatment facilities at various states. Table 4 shows the solid waste management facility plan: 9th Malaysia Plan [37].

Table 4 Municipal solid waste management facility plan: 9th Malaysia Plan [37]

Project/facilities	Operation capacity (tonnes per day)
Taman Beringin Transfer Station, Kuala Lumpur	1,700
Thermal treatment plan, Labuan	40
1st cell for Selong Sanitary Landfill, Johor Bahru	1,200
1st cell for Bukit Tagar Sanitary Landfill, Hulu Selangor	1,500

Thermal treatment is the reduction of waste volume aimed at the conversion of wastes into harmless materials. It is a process in which waste energy is converted into heat, steam, electrical or combustible material. However, several developed countries have shifted to use a non-thermal technology for the treatment of solid wastes [45]. Therefore, the country has to identify more effective alternative technologies without toxic by-products. Malaysia's solid waste management challenges could reasonably be addressed by the adaption of source reduction and reuse option, which is the most prepared option for the waste management strategy to achieve a cleaner technology [44]; [4]; [47]. These practices focus on volume reduction of wastes, including the switch to reusable products and packing. Thus, in order to gain environmental sustainability, the implementation of integrated solid waste management with regards to the environment needs to be coordinated and implemented. This approach is important because a country like Malaysia with a good economy can afford to acquire the technologies to make the process of waste management more efficient, thus, reduces

pollution and environmental degradation, and enhances the protection of public health. Downmore et al. (2011) [48] mentioned that the recycling of bio-degradable wastes into compost manure can be used to substitute chemical fertilisers in urban agriculture, which leads to reducing the volume of waste generation as well as water pollution by leachate, either from landfills or chemical fertilisers.

Conclusion

Municipal solid wastes represent a real hazard for human and environmental health. The management of these wastes in Malaysia is still in the developing stage. Malaysia has a strong regulation in the management and treatment of these wastes; however, the challenges lie in the absence of public awareness in terms of segregation and recycling of the recyclable wastes. More studies need to be conducted to evaluate the health risks and range of the contamination that occur via the disposal of the solid wastes into landfills.

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