Author: **Mohamed, Assoc. Prof. Dr. Ahmad Fariz**

Co-Author: Hadi, Emeritus Prof. Dr. Abdul Samad
Idrus, Mr. Shaharudin
Harman Shah, Assoc. Prof. Abdul Hadi

Intended Category: Beyond today's infrastructure

Title of Paper: **From the Linear to Cyclic Approach for Sustainable Waste Management in Malaysian City**

Contact information:
Associate Professor Dr Ahmad Fariz Mohamed
Institute for Environment and Development (LESTARI),
Universiti Kebangsaan Malaysia,
43600, Bangi, Selangor D.E., Malaysia
Tel: +6-03-89214149
Fax: +6-03-89255104
E-mail:afm3778@hotmail.com fariz@ukm.my,

Abstract

Cities in Malaysia are experiencing rapid changes and more resources have been consumed for its population and economic activities. Hence wastes generation from cities and economic activities increased significantly. The solid waste generation in Malaysian cities increases from 16,200 metric ton per day in 2001 to 19,100 metric ton in 2005 or an average of 0.8 kilogram per capita per day. It is estimated that solid waste generation will reach 30,000 metric ton per day in 2020. Managing waste generated by cities is a challenge in Malaysia. Since independence in 1957, waste has been managed through the linear approach which focuses on disposals to landfill. This linear approach creates difficulties and resulted to negative impact on the environment and human health. Moreover with the limitation of ecosystems carrying capacity it will have difficulty to accept more wastes. Being aware of these problems cities in Malaysia have embarked on many programs for sustainable waste management. The transition for sustainability focuses on waste recovery which includes recycling, reuse and reduces approaches. The transition process was strengthened when the Solid Waste and Public Cleansing Management Act 2007 was enacted. This act is the ultimate commitment by the government to manage waste in a sustainable manner with emphasize on waste separation and waste recovery at source. The Act was steered by the National Solid Waste Management Policy and The National Strategic Plan for Solid Waste Management. However to achieve sustainability a framework for transition is needed and must include a cyclic systems that promote waste minimization, waste recovery, waste exchange and support industry. The framework will ensure smooth transition from linear to cyclic approach where the ecosystem could maintain its carrying capacity. With this framework in place sustainable waste management in Malaysian cities will be accomplish in the future.

Keyword: Waste, recovery, management, transition, sustainability

Introduction

Malaysian cities experience growth for the past five decades. Depending on its geographical location and natural resource availability, cities sustainability requires the provision of environmental services that vary with the number of population, economic activity, development process and its metabolism rate. It is important for city to ensure its sustainability, especially in managing its metabolism process. This is to ensure enough input for its population needs and economic activities, and at the same time able to handle the output of the process. This balance of inputs and outputs had been described as urban metabolism (Wolman 1965; Boydon et al. 1981; Douglas 1983; Douglas et al. 2002).

Waste is the main important product generated from the cities metabolism process. Issues related to waste management in cities has been recognised by man since the early days of city establishment. Malaysia's comprehensive waste management establishment could be traced from 1918, when Seremban town established its own sanitary bill under its Town Planning committee. While for Malaya, the Sanitary Boards Bill 1929 was passed by the Federal Council on November 6, 1929, and The Sanitary Boards Enactment CAP 137 came into effect in 1930 incorporating Part IX of the Town Planning Act as the law.

The need for sustainable waste management is critical as it's generation increases with population growth and economic activity. This is true since as cities grow demand for consumption of resources will continue (Schulz, 2007, Fernandez, 2007). With increasing metabolism process, waste generation increases and that requires more services which include space, infrastructure and human resources. Cities with limited resources such as space will require strategic management system where they are able to manage their wastes in a sustainable manner. The most important is to implement waste recovery to reduce dependency on limited space, human resources and capital. Recycling becomes essential in turning around the linear process of urban metabolism. For a mature city, in which the input and output tend to be similar, recycled materials will be usable to replace a large portion of material inputs from outside (Xuemei, 2007).

This paper highlights what Malaysian cities have gone through in waste management. The trends of waste generation and its management issues were discussed. The transition of linear model of waste management focusing on end-of-pipe approach towards cycle of waste as resources, prioritising waste recovery will also be discussed.

Methodology

This research was conducted through an assessment of secondary data derived from government agencies, business and industries. A survey was conducted with senior officers or managers of government agencies, business and industries as the respondents. Data from the survey and the secondary data were analyzed with SWOT analysis (Houban et. al. 1999, Fleisher and Bensaussan, 2002). To understand the current status and trends of industrial waste generation and recovery, statistic analysis was conducted. The data collected from secondary source were analysed using cross tabulation (Mulley and Unruh, 2004) and simple percentage analysis (Rai and Lal, 2000).

Urban Growth and Waste Management in Malaysia

Since independence in 1957, urban expansion in Malaysia has been experiencing rapid change especially during the period from 1991 to 2000. Urban development and expansion has a direct relation with the increase in population. More areas within and outskirt of the urban areas are being used to develop more residential areas, industrial and business facilities, infrastructure and other important support systems. Table 1 and 2 provide the number of urban areas with respect to its population and the rate of population growth for each cities or town in Malaysia from 1970 to 2000.

Table 1: Number of Urban Centres in Malaysia

	Number of Urban Centres	
Population Number	**1991**	**2000**
Above 1,000,000	1	1
500,000 to 999,999	0	3
150,000 to 499,999	22	34
75,000 to 149,999	26	36
25,000 to 74,499	79	63
10,000 to 24,999	24	11

Source: Department of Statistic (DoS) 1992, 2000

Table 2: Metropolitan Centres and Population in Malaysia

Metropolitan/ Town	**Population (Thousands)**				**Average Annual Population Growth Rate**		
Year	**1970**	**1980**	**1991**	**2000**	**1970 - 1980**	**1980 - 1991**	**1991 - 2000**
Kuala Lumpur	451.8	919.6	1,145.30	1,305.79	7.1	2.1	1.3
Ipoh	248	293.8	468.3	529.9	1.7	4.2	1.2
Johor Bahru	136.2	246.4	441.7	769.66	5.9	5.3	5.5
Klang	113.6	192.1	368.4	562.23	5.2	5.9	4.2
Petaling Jaya	92.7	207.8	351	432.62	8.1	4.8	2.1
Kota Bharu	55.1	167.9	234.6	360.6	11.1	3	4.3
Kuala Terengganu	53.3	180.3	228.1	298.3	12.2	2.1	2.7
Georgetown	269.2	248.2	219.6	416.36	-0.8	-1.1	6.4
Kuantan	43.3	131.5	202.4	282.34	11.1	3.9	3.3
Seremban	80.9	132.9	193.2	245.98	5	3.4	2.4

Source: Department of Statistic (DoS) 1992, 2000

Rapid urban growth and its metabolism process in Malaysian cities lead to generation of significant amount of waste mainly from domestic and industries. The amount of solid waste generated in Malaysia increased from 16,200 tonnes per day in 2001 to 19,100 tonnes in 2005 or an average of 0.8 kilogram per capita per day (JICA, 2006). Studies conducted by Hassan et al. (1998 reveal that Malaysian municipal solid waste (MSW) generation ranges between 0.45 and 1.44 kg waste/capacity/day with an average 0.81kg waste/capita/day. The volume of wastes generated within the urban areas managed by the local government is shown in Table 3. Obviously, the amount of MSW increases significantly with the increasing number of population, where the amount of MSW managed by local government increases from 2.5 million tons in 1991 to 4.6 million tons in 2002 as shown in Table 3. As a result of which, a proper management system is required urgently to manage waste in a sustainable manner.

Table 3: Estimated Municipal Solid Wastes (MSW) Generation in Urban Areas

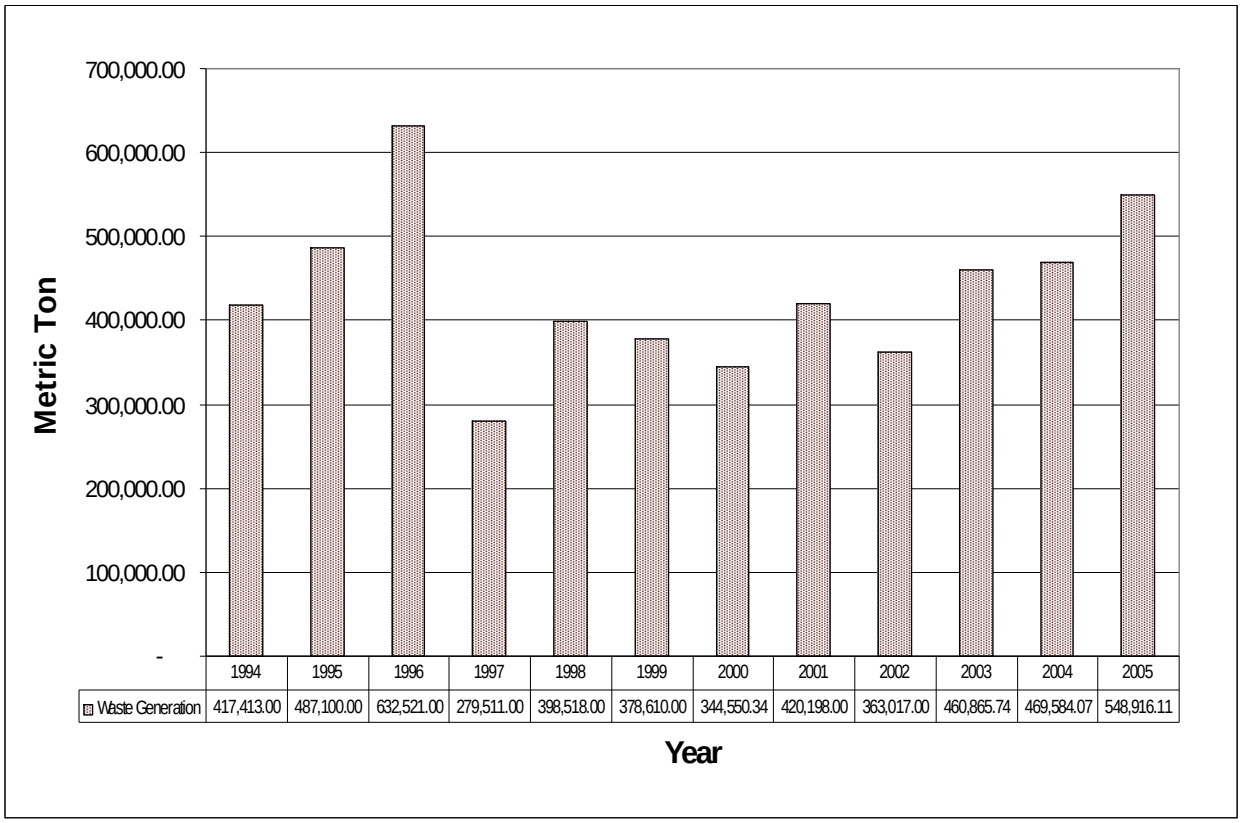
Year	Population Live in Local Government Area (million) (increase 3% annually)	Estimated Solid Wastes Manage by Local Government (Million ton)
1991	13,727	2.5
1992	14,139	2.6
1993	14,563	2.8
1994	15,000	2.9
1995	15,146	3.0
1996	15,450	3.2
1997	15,524	3.4
1998	16,312	3.5
1999	16,310	3.7
2000	16,718	3.9
2001	17,136	4.5
2002	17,564	4.6

Source: MHLG, 2004.

Industrial scheduled waste generation trends from industry in urban areas varied from 417,413 metric tons in 1994, increase to 632,521 in 1996 then reduced to 363,017 metric tons in 2002, increased again to 548,910 metric tons in 2005 as shown in Figure 2. Industry also generated solid wastes. It is estimated that the industrial solid wastes generation had increased from 7,721.58 ton/day in 1994 to 11,519.24 ton/day in 2005. Hassan et. al. (1998) found that industries in Malaysia contributed 30% of solid wastes and the wastes generation increased was estimated at about 4% annually.

The current system practice for solid waste management focuses on end-of-pipe approach that requires numbers of large disposal sites. As of 2002, there are 161 landfills available in Malaysia, with different categories and life span ranging from 2 to 8 years. As of for the scheduled wastes (hazardous waste) although it been handle in a safe and environmental friendly manner however the end output of the waste treatment still end up in the landfill. Thus if the current management practice is going to be maintained, while wastes generation increases within the existing rate, there will be an increasing demand for new land to be alienated for disposal sites. Hence this will create competition of landuse between population expansion needs, economy activities and waste disposal requirements.

Figure 2: Scheduled Waste Generation Malaysia 1994 - 2005



Source: DoE 1995, 2003, 2006.

The Need for Change from Linear to Cyclic Approach in Urban Waste Management

Each year waste generation by Malaysian cities from its population, economic and industrial activities have been found increasing. Waste has become important issues in the cities, for example in from 1998 to 2007 the Ministry of Housing and Local Government provided additional fund for all local government amounted to USD 20.7 million on top of it's existing budget for waste management (MHLG, 2009). In fact almost 30 – 40% of local government expenditure was used for waste management. The main approaches in managing waste still maintain end-of-pipe approach where disposal of waste to landfill is a priority. Approximately 95 - 97% of wastes collected in Peninsular Malaysia are brought for final disposal at landfills while the remaining 3 to 5% are diverted to recyclers or re-processors and or self treated (JICA, 2006). Thus waste stream in Malaysian cities still goes into the environment and affects the health of the ecosystem. The critical issue with this approach is, it requires more space and suitable land for landfill purposes. As more land is used for disposals, it will create more contaminated land and which may not suitable for other uses, such as for property and agriculture. Moreover land availability for wastes disposals in cities boundary has become limited and expensive to maintain. Expansion of housing areas which encroaches on existing landfill demands the landfill to be closed as soon as possible, due to its odour, leachate pollution and aesthetic problems. However since waste generation from cities increases in volumes, the existing practice and space are unable to handle efficiently within the city boundary. This leads to illegal dumping of wastes into many secluded areas such as plantations, rivers, lakes and ex-mining pools. This practice pollutes the ecosystem and affects the quality of natural resources such as water and soil.

The problem will continue if wastes are seen as a non valuable resource and maintain linear approach. There is need to change the view of waste and approach in waste management. Changing the perception of wastes as a valuable resources and implementation of cyclic approach for waste management will reduce dependency of ecosystem as space for waste disposals. Wastes recovery as part of cyclic approach in managing waste was introduce and Malaysian government has initiated program for waste recycling since 1994, conducted by Ministry of Housing and Local Government (MHLG) and Ministry of Science, Technology and Environment. The program started voluntarily by NGO's and multi-national companies focusing on urban and industrial areas in Malaysia. As of 2002, there are 170 recycling centres were setup in all the states (Table 4). Although with government supports the recycling program has been found not successful, only estimated 5% of the total wastes generated from 1999 – 2007 were recycled. There are many factors contributing to the low achievement of the waste recycling program. The factor includes culture, infrastructure, management system, economic support, technological input, human resources and awareness. However the transition of moving away from linear end-of-pipe approach towards waste recovery has been established, progress with a small step. In order to achieve a significant transition for change in waste management, there is need to identify approach which leads to sustainability. Using concept of wastes as a resource, the cyclic approach will use wastes as an important resource in the urban ecosystem.

Table 4: Recycling Centres in States of Malaysia 2002

State	Total
Johor	23
Melaka	4
Negeri Sembilan	19
Selangor	15
Perak	23
Kedah	13
Pulau Pinang	8
Perlis	5
Pahang	22
Terengganu	0
Kelantan	0
Sarawak	22
Sabah	13
W.P. Kuala Lumpur	3
Total	**170**

Source: MHLG, 2004.

Continuous flow of materials or resources within the urban ecosystem will ensure efficiency of its metabolism process. The existing linear flow will not able to sustain increasing demand of material or resources for the urban ecosystem in Malaysia. Wastes recycling in Malaysian cities are becoming important activities. With increasing amount of solid waste generated each year and reduction of natural resources supply it creates more opportunities. Recovery of wastes, using cycle of materials flow concepts and changes of manufacturing process with technology development, will create alternative resources and promote costs efficiency (Leu and Lin, 1998; Orloff and Falk, 2003). Moreover with government support through policy, legislation, and economic it will become important activity in the urban ecosystem in the

future. With more than 170 recyclers in the Malaysian cities, this illustrate that waste recycling is not only able to reduce impact to the environment, it also create economic opportunities. It is estimated that 70% of total industrial solid wastes generated were recovered. Industrial solid wastes recovered 5,405.1 ton/day in 1994, and increased to 8,063.47 ton/day in 2005. Approximately 45.75% of scheduled wastes have been recovered from total wastes generation from 2000 to 2005. Increasing trend of wastes recovery is observed, from 35% in 2000 to 58% in 2004. Between years 2000 to 2005, 1.12 million metric ton of industrial scheduled waste has been recovered.

Waste as alternative resources in practice are not only being recovered through 3R approaches. Initiatives to use waste as energy materials has been started in Malaysia. Example of waste recovery is waste to energy done by Recycle Energy. The company incinerated domestic waste to produce energy. It has a capacity of processing 700 tons of MSW per day at its Refuse Derive Fuel - Waste to Energy (RDF-WTE) plant in Semenyih for the Kajang Municipal Council and district of Hulu Langat. The plant has the capacity to produce 5 Megawatt (MW) of electricity per month which was supplied to the national grid. They have a plan to process solid wastes generated by Ampang Jaya Municipal Council before 2015.

Framework for Sustainable Waste Management in Malaysian City:

The need for efficient waste management in urban ecosystem is very important to assure the sustainability of city in the future and to achieve sustainable development. The cyclic approach has been identified as an approach which emphasizes resource recovery and ensure in achieving the ultimate objective of an economy that cycles virtually all of the materials it uses, emitting only micro amounts of wastes and pollutants within the urban ecosystem. The main factors in making the urban ecosystem works are to understand the integration and synergism of stakeholders, resources and support system. However to implement ecosystem approach will require paradigm shift form all key stakeholders especially by the government agencies, communities, industries and business. This paradigm shift will need to look at more holistic approach which encompasses all the important key factors for sustainable waste management. There are four important factors which play important role for sustainable waste management in the urban ecosystem; legislation, institutional, financial and technology. The four must be integrated into a holistic system to make the urban ecosystem work.

In Malaysia, although cyclic approach has not being implemented, the latest development however shows that it is prioritizing approaches which protect the environment and sustaining ecosystem function and services. The transition is shown here. Previously the solid wastes management falls under the jurisdiction of Local Government Act 1976, Street, Drainage and Building Act, 1974 and Town and Country Planning Act. While scheduled wastes are directly managed under the Environmental Quality Act (Scheduled Wastes), Regulation 1989. These two legislations are not equipped with requirements for waste recovery system and prioritize linear approach. Therefore the government has reviewed the law and established more comprehensive legislative tools for sustainable waste management in Malaysia and promote use of cyclic approach.

The reviewed process established policy and legislation for waste management, specifically for solid waste. The National Solid Waste Management Policy 2007 and the Solid Waste and Public Cleansing Management Act (SWPCMA) 2007 were established to prioritize waste minimization and recovery as a resource. While for schedule wastes Environmental Quality

Act 1974, Schedule Waste Regulation 2005 promotes schedule wastes recovery as a resource with a special requirement.

SWPMA steered by the National Solid Waste Management Policy and The National Strategic Plan for Solid Waste Management. SWPMA will implement sustainable waste management based on waste management hierarchy which prioritizes waste reduction through 3R, intermediate treatment and final disposal as well as emphasis on environmental protection and public health (Abdul Nasir, 2007). However there is a need for efficient urban ecosystem in managing resources consumption and waste generation. A strategic framework to improve knowledge and decisions about materials use, waste reduction and pollution prevention must be established within the urban ecosystem institutional mechanism. This framework will include systems that promote waste minimization, waste recovery, waste exchange and conservation. In addition cities will experience economical and environmental benefits that follow, improved material efficiency, energy efficiency and wastes recovery (Sheila et.al., 1998; Mato and Kaseva, 1999).

Conclusion

Complex impact from increasing number of population and activity within the cities require multi-dimension action. Hence in handling such impact cities need to be managed as an ecosystem. For example waste management approach in cities in Malaysia the needs for changed is important as the impacts become critical to the health of the urban ecosystem and its people. Therefore waste management system changes from linear approach to cyclic approach focusing on waste recovery as resource will help to minimize impacts and create many opportunities. This includes promoting environmental conservation, resources efficiency, creation of alternative resource for industry, creation of jobs and new economic sectors. Moreover urban ecosystem will be able to maintain its function as more land could be used for other purpose than as a landfill for waste. However a management framework is needed within which to improve knowledge and decisions about materials use, waste reduction and pollution prevention. This management framework will include systems that promote waste minimization, waste recovery, waste exchange and environment conservation. With this approach in place will ensure the urban ecosystem to maintain its ecosystem function and services for sustainable development. However changing existing approach towards ecosystem approach is not an easy task. There is a need to determine key obstacles and to identify strategy to implement the cyclic approach for sustainable waste management in city. The main obstacles which require thorough analyses include legislation, culture, technology, infrastructure, institutional and financial.

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