Akademika 81(2) 2011: 71-78

Ecological Transition: From the End-of-Pipe to Ecosystem Approach for Waste Management in Malaysian City

Peralihan Ekologi: Dari Pengakhiran kepada Pendekatan Ekosistem untuk Pengurusan Sisa dalam Bandar Raya Malaysia

Ahmad Fariz Mohamed, Abdul Samad Hadi, Shaharudin Idrus & Abdul Hadi Harman Shah

ABSTRAK

Ekosistem semula jadi di bandar-bandar Malaysia kini sedang mengalami perubahan yang pesat. Proses pembangunan bandar telah mengubah ekosistem semula jadi kepada pelbagai jenis guna tanah mengikut keperluan pembangunan manusia. Pertambahan penduduk dan kawasan bandar yang berkembang pesat, maka lebih banyak tanah telah digunakan untuk aktiviti ekonomi dan menyokong keperluan kehidupan populasi bandar. Tambahan pula lebih banyak sumber telah digunakan untuk keperluan penduduk dan aktiviti ekonomi terutamanya oleh industri dan perniagaan. Sehubungan dengan itu penghasilan sisa dari aktiviti bandar dan ekonomi telah meningkat. Pengurusan sisa yang dihasilkan oleh bandar merupakan satu cabaran yang penting di Malaysia. Sejak merdeka pada tahun 1957, pengurusan sisa di Malaysia telah dilakukan dengan menggunakan pendekatan hujung-paip yang mengutamakan pelupusan terus sisa di tapak pelupusan. Amalan ini telah mewujudkan masalah dan memberi kesan negatif kepada alam sekitar dan kesihatan manusia serta mengganggu fungsi ekosistem selain menurunkan nilai tanah di masa hadapan. Sejak 1980 pengurangan sisa dan penggunaan teknologi bersih telah diperkenalkan. Langkah besar untuk pengurusan sisa di bandar-bandar Malaysia secara lestari telah disokong dengan wujudnya Akta Pengurusan Sisa Pepejal dan Pembersihan Awam 2007. Akta ini merupakan komitmen utama Kerajaan Malaysia untuk mengurus sisa dengan lestari melalui penekanan kepada pengasingan sisa daripada sumber dan pengembalian semula sisa. Ini adalah titik perubahan kritikal kepada pengurusan sisa lestari di Malaysia. Ia juga merupakan titik tolak perubahan pengurusan sisa dari pendekatan linear kepada kitaran. Dasar dan akta ini akan memastikan fungsi dan perkhidmatan ekosistem bandar-bandar di Malaysia akan terus dapat menampung peningkatan isipadu sisa yang dihasilkan. Satu kerangka diperlukan dalam usaha untuk menambah baik pengetahuan dan keputusan bagi penggunaan bahan dan pengurangan sisa. Ini termasuk pendekatan untuk penglibatan lebih meluas masyarakat dan individu dalam menjayakan dasar dan strategi tersebut. Sehubungan dengan itu keperluan kecekapan untuk ekosistem bandar dalam mengurus penggunaan sumber dan penghasilan sisa adalah sangat penting dalam usaha untuk mengekalkan fungsi ekosistem dan perkhidmatan bandar untuk pembangunan lestari.

Kata kunci: Sisa; pengembalian semula; ekosistem; transisi; pembangunan lestari

ABSTRACT

Cities in Malaysia are experiencing rapid changes of their natural ecosystem. The development process of cities has transformed natural ecosystem into many types of land use in accordance with human development needs. As population grows and urban expands, waste and economic activities have also continued significantly over the decades. Since Malaysia's independence in 1957, waste has been managed through the end-of-pipe approach which focuses on disposals of wastes to landfill. This practice gives negative impact to the environment and human health. Moreover, this approach increases costs to wastes generator and more landfills are required. The ecosystem functions are affected, and land value will decline there in the future. Being aware of these problems, cities in Malaysia have embarked on many programs in managing wastes in a sustainable manner. One of the activities is through recovery of waste as resources and these include recycling, reuse and reduce or 3R approaches. Since 1980s waste minimisation and the use of cleaner technology have been introduced. Therefore, the need for efficient urban ecosystem in managing resources consumption and waste generation is very important. A framework is needed within which to improve knowledge and decision making about materials used, waste reduction and pollution prevention. This framework will include systems that promote waste minimisation, waste recovery, waste exchange and conservation. Ultimately using natural ecosystem approach for cities to manage its wastes will ensure that it will be able to maintain its ecosystem functions and services for sustainable development.

Keyword: Waste; recovery; ecosystem; transition; sustainable development

INTRODUCTION

City growth with increasing population will increase demand for environmental services. Depending on its geographical location and natural resource availability, cities sustainability to provide environmental services varies with the number of population, the range of economic activities, development process and metabolism rates. One of the critical areas for city sustainability is to manage its metabolism process, by providing enough input for its population needs and economic activities, and at the same time it is able to handle the output of the process. Formally, this balance of inputs and outputs has been described as urban metabolism (Wolman 1965; Boydon et al. 1981; Douglas 1983; Douglas et al. 2002).

Waste is the main important item generated from the city metabolism process. Issues related to waste management in cities have been recognised by man since the early days of city establishment. In 500 BC, Athens had established probably the first municipal dump for waste, located at least one mile from the city limits. In Japan, waste management began systematically around 8th and 9th centuries with records indicating specific individuals assigned to manage waste. During the Edo Period (17th Century) waste management came under the jurisdiction of the Machibugyo (Public Officials). The authority established orders to prohibit unauthorised waste dumping and promoted recycling and recovery especially for agriculture.

Malaysia's comprehensive waste management establishment could be traced from 1918, when Seremban town established its own sanitary bill under its Town Planning committee. For Peninsular Malaysia (Malaya), the Sanitary Boards Bill 1929 was passed by the Federal Council only 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 at present as its generation increases with the growing population and economic activities. As cities grow the consumption of resources will continue to increase (Schulz 2007; Fernandez 2007). With increasing city metabolism process, waste generation increases. The situation requires more environmental services which include space, infrastructure and human resource. Cities with limited resources such as space will require strategic management system that will help to manage their wastes in a sustainable manner. The most important system is to implement waste recovery to reduce dependency on limited space, human resource 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 article will highlight that Malaysian cities have gone through the process in waste management. The trends of waste generation and its management issues are discussed. The transition of linear model of waste management focusing on end-of-pipe approach towards cycle of waste as resources, prioritising waste recovery with an ecosystem approach will also be discussed.

URBAN GROWTH AND POPULATION INCREASE

Development and economic activity have been the important drivers of urban development in Malaysia in the past decades. 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 have a direct relation with the increase in population. More areas within and the outskirt of the urban areas are being used to develop more residential areas, amenities, infrastructures and other important support systems. Tables 1 and 2 provide the number of urban areas with respect to their population size and the rate of population growth for each city or town in Malaysia from 1970 to 2000.

TABLE 1. Number of Urban Centres in Malaysia

Population Number	Number of Urban Centres	
	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

URBAN WASTE IN MALAYSIAN CITIES

Waste generation is another important component that is highly correlated with urban growth. 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 Nasir et al. (1998) and Hoonwerg (2000) reveal that Malaysian municipal solid waste (MSW) generation ranges between 0.45 and 1.44 kg waste/capacity/day with an average of 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 increasing number of population, where the amount of MSW managed by local government increases from 2.5 million ton in 1991 to 4.6 million ton in 2002. As a result of which, a proper management system is required urgently to manage waste in a sustainable manner.

TABLE 2. Metropolitan Centres Population in Malaysia

Metropolitan/Town	Population (Thousands)				Average Annual Population Growth Rate		
	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 (Johor City Council & Johor Bahru Tengah Local Council)	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 (Kota Bharu Town Council & Kota Bharu Local Council)	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

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: KPKT, 2004

The current waste management system focuses on the end-of-pipe approach that requires larger disposal sites. As of 2002, there were 161 landfills available in Malaysia, with different categories and life span ranging from 2 to 8 years. 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 disposals sites. Hence, this will create competition among land use between population expansion needs, economic activities and waste disposal requirements.

URBAN GROWTH AND INDUSTRIAL ACTIVITIES

Industrial sector plays a very important role in economic growth of Malaysia. Industrial activities not only provide job opportunities to urban population (as most of industrial areas or parks are located within or at the fringe of the urban areas), but also economic returns to the government. By 2002, the amount of foreign direct investment (FDI) accounted for more than RM12.2 billion although there was a slight drop in the previous year (Figure 1). In terms of energy consumption, industrial and commercial users accounted for over 80 percent of the total consumption with less than 20 percent by domestic consumers (Peterson et al. 2003).

However, there is also a negative impact as a consequence of increasing industrial activities. The impact has been found to be critical. Certain factories have been identified as the main polluters to river

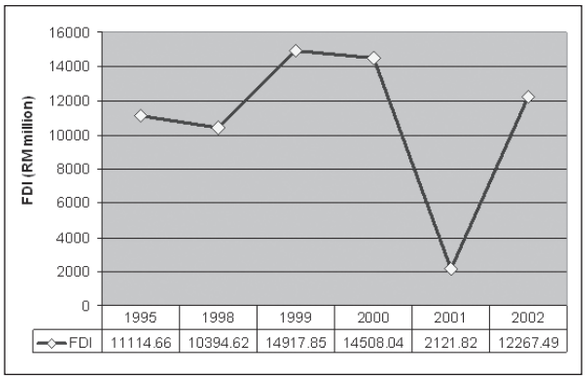


FIGURE 1. Foreign Direct Investment in Malaysia 1995 to 2002
Source: UNCTAD 2003

systems and air quality. Waste generation from industry then requires special handling system. Among the main pollutants generated by the industries are noxious gas, toxic and hazardous wastes, including hazardous materials from metal processes, solvent and paint sludge, refinery and petrochemical sludge, semiconductor plant waste, etc. from around 3,450 industries in the country (DOSH 2001).

Industrial scheduled waste generation trends from industry in urban areas varied from 417,413 metric tons in 1994, increased to 632,521 in 1996, then reduced to 363,017 metric tons in 2002, but increased again to 548,910 metric tons as shown in Figure 2 (DOE 2000; 2003). The handling of schedule waste includes export and import activities, and the trend of toxic and hazardous wastes export and import is shown in Figure 3 (DOE 2003). There is significant relationship between industrial waste generation and industrial production.

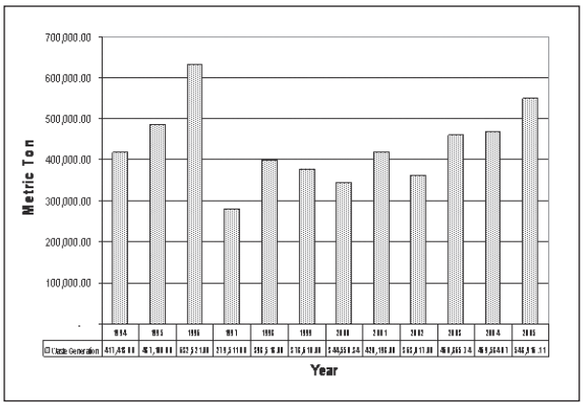


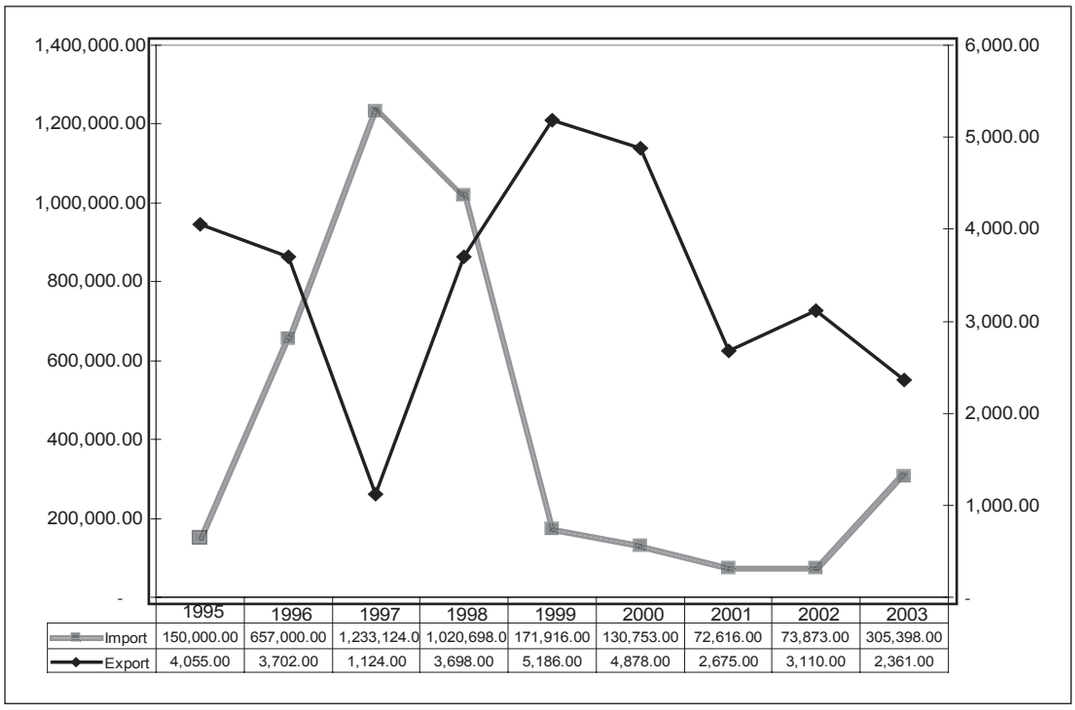
FIGURE 2. Scheduled Waste Generation Malaysia 1994-2005
Source: DOE 1995, 2003, 2006.

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. Nasir et al. (1998) found that industries in Malaysia contribute 30 percent of solid wastes, and the wastes generation increase was estimated at about 4 percent annually.

WASTE MANAGEMENT ISSUES IN MALAYSIAN CITIES

Each year waste generation by Malaysian cities increases, generated by its population, economic and industrial activities. Waste has become important issue in the cities. For example, from 1998 to 2007 the Ministry of Housing and Local Government of Malaysia provided additional fund for all local governments, amounted to RM68.4 million, on top of their existing annual budget for waste management (KPKT 2009). In fact almost 30 to 40 percent of local government expenditures was used for waste management.

The main approach in managing waste however still maintains the end-of-pipe approach where disposal of waste to landfill is a priority. Approximately 95 - 97 percent of wastes collected in Peninsular Malaysia are brought for final disposal at landfills while the remaining 3 to 5 percent are diverted to recyclers or re-processors



	1995	1996	1997	1998	1999	2000	2001	2002	2003
Import	150,000.00	657,000.00	1,233,124.0	1,020,698.0	171,916.00	130,753.00	72,616.00	73,873.00	305,398.00
Export	4,055.00	3,702.00	1,124.00	3,698.00	5,186.00	4,878.00	2,675.00	3,110.00	2,361.00

FIGURE 3. Import and Export of Scheduled Waste from 1996 to 2003.
Source: Department of Environment (2004).

and or self treatment (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 be suitable for other uses, such as for housing and agriculture. Moreover, land availability for waste disposal within city boundary has become limited and expensive to maintain. Expansion of housing areas which encroaches on existing landfills demands the existing landfills 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 (in ton), the existing management practice limits the ability of available space to handle the wastes 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 has polluted the ecosystem and affects the quality of ecosystem resources such as water and soil.

The problem will continue if wastes are regarded as a non valuable resource. There is a need to change the view, where wastes are seen to have economic values. Changing the perception from looking at wastes as useless remains to valuable resources will reduce dependency of ecosystem as space for waste disposals. Therefore, wastes recovery was introduced by the Malaysian government in 1994 to initiate programs for waste recycling under the purview of the Ministry of Housing and Local Government (MHLG) and the 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. However, poor participation from the concerned party led to non-achievement. Aware of the need for waste recovery, MHLG has embarked on programs for solid waste recycling in all cities in Malaysia. As of 2002, there were 170 recycling centres, setup in all states in the country (Table 4). Although with government support the recycling program was only able to recycle 3 - 5 percent of the total wastes generated from 1999 – 2007. However, it is believed that the rate of recycling of waste in Malaysia is more than 5 percent. It is estimated that the rate have reach 8 to 10 percent from total solid waste generation. There are many factors contributing to the low achievement of the waste recycling program. The factors include culture, infrastructure, management system, economic support, technological input, human resources and people's awareness. However, the transition of moving away from the end-of-pipe approach towards waste recovery has been established, progressing in small steps. In order to achieve a significant transition for change in waste management, there is a need to identify an approach which leads to zero waste sustainability.

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: KPKT 2004.

In managing urban wastes, the ecosystem approach could be used towards achieving sustainable waste management. Using the concept of wastes as a resource, the ecosystem approach will use wastes as an important resource input in the urban ecosystem. By mimicking the natural ecosystem, wastes could be used as important alternative resources in the urban ecosystem.

TRANSITION: ECOSYSTEM APPROACH TO SUSTAINABLE WASTE MANAGEMENT

The need for efficient waste management in an urban ecosystem is very important to assure the sustainability of city in the future and to achieve sustainable development. Ecosystem approach has been identified as an approach which emphasizes resource recovery. Such recovery ensures the progress in achieving the ultimate objective of an economy that recycles virtually all of the materials used, 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 synergy among stakeholders, resources and support system. However, to implement the ecosystem approach will require a paradigm shift for all key stakeholders especially among the government agencies, communities, industries and business sector. 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, namely legislation, institutional, financial and technology. The four must be integrated into a holistic and functional system to make the urban ecosystem work for waste management.

In Malaysia, although it is not clearly stated that the government is implementing the ecosystem approach, the latest policy development with regard to waste management shows that it is prioritising approaches which protect the environment and thus sustaining ecosystem functions and services. Hence, going from the latest development in policy and legal system for waste management, that is prioritising waste recovery and waste minimisation, the government does show commitment and seriousness. The management transition shown here is for sustainable waste management involving both domestic and industrial waste. Previously, the solid wastes management falls under the jurisdiction of the 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 legislations are not equipped with requirements for waste recovery system. Therefore, the government has reviewed the existing laws, and then establishes more comprehensive legislative tools for sustainable waste management that encourages waste recovery as a resource through reduce, reuse and recycle (3R) approach.

The reviewed process established the policy and the 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 prioritise waste minimisation and recovery as a resource. While for schedule wastes Environmental Quality Act 1974, and Schedule Waste Regulation 2005 promote schedule wastes recovery as a resource with a special requirement.

SWPCMA is steered by the National Solid Waste Management Policy and The National Strategic Plan for Solid Waste Management. SWPCMA will implement sustainable waste management based on waste management hierarchy which prioritises waste reduction through 3R, intermediate treatment and final disposal as well as emphasising on environmental protection and public health (Abdul Nasir 2007). These policy and acts will ensure that the ecosystem functions and services of the Malaysian cities will be able to support the increasing volume of wastes generated. However, there is a need for efficient urban ecosystem in managing resources consumption and waste generation. A strategic framework, aiming to improve stakeholders' knowledge and decisions about materials use, waste reduction and pollution prevention must be established within the urban ecosystem and institutional mechanism. This framework will include systems that promote waste minimisation, waste recovery, waste exchange and conservation. Ultimately, using natural ecosystem approach for city waste management will ensure that the city will be able to maintain its ecosystem functions and services for sustainable development. In addition, cities will experience economic and environmental benefits that follow from improved material and energy efficiency and wastes recovery (Sheila et al. 1998; Mato and Kaseva 1999).

WASTE RECOVERY: A KEY ACTIVITY FOR URBAN ECOSYSTEM METABOLISM PROCESS

Continuous flow of material or resources within the urban ecosystem will ensure the efficiency of its metabolism process. The existing linear flow will not be able to sustain the increasing demand for material or resources by the urban ecosystem in Malaysia. Waste recovery as an alternative resource with the ecosystem approach as the main platform is one of the main options. Waste recovery in this instance needs to include waste minimisation and recycling.

There are two central waste minimisation strategies that can be adopted. The first is to deal with the waste after it has been generated, and then to mitigate its effects on the environment. The second is to minimise the amount of waste generated in the first place, thereby reducing the amount of mitigation required at the end of the pipe. Even when financial returns are not an immediate concern, most waste minimisation exercises are as cost-effective as waste treatment or disposal.

Waste recycling in Malaysian cities is increasingly becoming important economic activities. With increasing amount of solid waste generated each year together with continuing reduction of natural resources supply, waste recycling creates more opportunities. Recycling of wastes, using cycle of materials flow concepts together with changing manufacturing process supported by 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 an important activity in the urban ecosystem in the future. With more than 170 recyclers in the Malaysian cities, waste recycling will not only be able to reduce waste impacts on the environment but it will also create economic opportunities. It has been estimated that 70 percent of total industrial solid wastes generated had been recovered before. The industrial solid wastes that had been recovered were 5,405.1 ton/day in 1994; and the amount increased to 8,063.47 ton/day in 2005. Approximately 45.75 percent of scheduled wastes was recovered from the total wastes generation from 2000 to 2005. An increasing trend of wastes recovery has also been observed, from 35 percent in 2000 to 58 percent in 2004. From the year 2000 to 2005, 1.12 million metric tons of industrial scheduled waste had been recovered.

Waste as alternative resources in practice has been recovered through the 3R approaches. Initiative to use waste as energy materials has been started in Malaysia. An example of waste recovery is waste to energy done

by Recycle Energy company. 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 the 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. The Council has a plan to process solid wastes generated by the Ampang Jaya Municipal Council before 2015.

CONCLUSION

As cities grow, demand for efficient ecosystem function services will increase. Complex impacts from increasing number of population and its activity within the cities require multi-dimensional action. Hence, in handling such impact cities need to be managed as an ecosystem. For example, waste management approach in cities in Malaysia needs to be changed as the impact becomes critical to the health of the urban ecosystem and its people. Waste management system changes from land-filling to recovery of waste as resource that creates many opportunities. In addition it promotes environmental conservation, resources efficiency, the creation of alternative resource for industry, and hence the creation of jobs and new economic sectors.

Moreover, the urban ecosystem will be able to maintain its function as more land could be used for other purposes, other than as a landfill for waste. With reduced wastes going to the landfill, the ecosystem will receive reduced impacts on the soil and groundwater, thus helping to minimise impacts on the water quality of river system. A management framework, the natural ecosystem, has been developed to improve stakeholders' knowledge and thereby decision-making about materials use, waste reduction and pollution prevention. This framework will include systems that promote waste minimisation, waste recovery, waste exchange and conservation. Ultimately, using the natural ecosystem approach for cities to manage their wastes will ensure that they will be able to maintain their ecosystem functions and services for sustainable development. However, changing the existing management approach towards using natural ecosystem approach is not an easy task. There is a need to determine key obstacles and to identify the strategy to implement the natural ecosystem approach for sustainable waste management in a city. The main obstacles which require a thorough analysis include the current legislation, culture, and technology, infrastructure, institutional and financial.

REFERENCES

Abdul Nasir Abdul Aziz. 2007. *Institutionalising Solid Waste Management in Malaysia. Department of National Solid Waste Management*. Kuala Lumpur: Ministry of Housing and Local Government Malaysia.

Boydon, S., Millar, S., Newcombe, K and O'Neill, B. 1981. *The Ecology of a City and its People, the Case Study of Hong Kong*. Canberra: Australian National University Press.

Department of Environment Malaysia (DOE), 1995. *Malaysia Environmental Quality Report* 1994. Kuala Lumpur.

_____. 2000. *Malaysia Environmental Quality Report 1999*. Kuala Lumpur.

_____. 2003. *Malaysia Environmental Quality Report 2002*. Putrajaya.

_____. 2004. *Malaysia Environmental Quality Report* 2003. Putrajaya.

Department of Statistic (DOS). 1992. *Census of Housing and Population 1990*. Kuala Lumpur: Government of Malaysia Printers.

_____. 2000. *Census of Housing and Population 1990*. Kuala Lumpur: Government of Malaysia Printers.

Douglas, I. 1983. *The Urban Environment*. London: Edward Arnold.

Douglas, I., R. Hodgson, and N. Lawson. 2002. Industry, Environment and Health Through 200 Years in Manchester. *Ecological Economics* 41(2): 235-255.

Fernandez, J. E. 2007. Resource Consumption of New Urban Construction in China. *Journal of Industrial Ecology* 11(2): 99-115.

Hoonwerg, D. 2000. What is Waste: Solid Waste Management in Asia. *UNEP Industry and Environment* 23: 65-70.

JICA. 2006. *The Study on National Waste Minimisation in Malaysia*. Kuala Lumpur: Ministry of Housing and Local Government Malaysia.

JPBD. 2003. *Selangor Infrastructure Master Plan Study*. Selangor: Jabatan Perancangan Bandar dan Desa (JBPD).

KPKT. 2004. Perangkaan Kementerian Perumahan dan Kerajaan Tempatan (KPKT) 2002. Access on 18.09.2004. http://www.kpkt.gov.my/statistik/perangkaan2002/kandungan.htm.

Kementerian Perumahan dan Kerajaan Tempatan (KPKT). 2009. *Annual Report 2009*.

Leu, H.G. and Lin, S.H., 1998. Cost–benefit Analysis of Resource Material Recycling. *Resources, Conservation and Recycling* 23 (1998) 183-192.

Martin, S. A., Cushman, R. A., Weitz, K. A., Aarti Sharma and Lindrooth, R. C. 1998. Applying Industrial Ecology to Industrial Parks: An Economic and Environmental Analysis. *Economic Development Quarterly* 12(3): 218-220.

Mato, R.R.A.M. and Kaseva, M.E., 1999. Critical Review of Industrial and Medical Waste Practices in Dares Salaam City. *Resources, Conservation and Recycling* 25: 271-287.

Nasir, M.H, Kamil, M.Y, Azmin, S.N and Rakmi, A.R. 1998. Issues and Problems of Solid Waste Management. In *National Review on Environmental Quality Management in Malaysia; Towards the Next Two Decades*, edited by Mohd Nordin Hasan et al. 179-225. Bangi: Institute for Environment and Development, Universiti Kebangsaan Malaysia.

Orloff, K. and Falk, H. 2003. An International Persepective on Hazardous Wastes Practice. *International Journal of Hygene and Environmental Health* 206: 291-302.

Peterson, P.J., Fariz, A.M. and Mazlin, B.M. 2003. Indicators of Sustainable Development in Industrializing Countries, Volume 5. Measuring Industrial Change in Malaysia: Linking Strategies with National Policies. Bangi: Institute for Environment and Development (LESTARI).

Schulz, N. B. 2007. The Direct Material Inputs into Singapore's Development. *Journal of Industrial Ecology* 11(2): 117-131.

Wolman, A. 1965. The Metabolism of Cities. *Scientific American* 213(3): 179-190.

Xuemei Bai. 2007. Industrial Ecology and the Global Impacts of Cities. *Journal of Industrial Ecology* 11(2): 1-6.

Ahmad Fariz Mohamed, PhD
Institut Alam Sekitar dan Pembangunan (LESTARI)
Universiti Kebangsaan Malaysia (UKM)
43600 Bangi
Selangor, Malaysia

Abdul Samad Hadi, PhD
Institut Alam Sekitar dan Pembangunan (LESTARI)
Universiti Kebangsaan Malaysia (UKM)
43600 Bangi
Selangor, Malaysia

Shaharudin Idrus
Institut Alam Sekitar dan Pembangunan (LESTARI)
Universiti Kebangsaan Malaysia (UKM)
43600 Bangi
Selangor, Malaysia

Abdul Hadi Harman Shah
Fakulti Sains Sosial dan Kemanusiaan (FSSK)
Universiti Kebangsaan Malaysia (UKM)
43600 Bangi
Selangor, Malaysia