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Waste Management and Recycling in Asia

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This paper provides an overview of solid waste generation and management in Asia, which, with rapid economic growth and urbanization, is becoming a major social and environmental issue. Every country or region within Asia has its own background and characteristics in relation to solid waste management and material-cycle policy, even though they share the same global region. Municipal solid waste (MSW) generation ranges between 0.5 kg and 1.4 kg per capita per day in all countries and regions within Asia (with the exception of China). As gross domestic product (GDP) per capita increases, MSW per capita generation also increases and MSW generation becomes saturated at high GDP. This relationship could be made clearer using detailed data from some countries. Organic matter is the main component of MSW in Asia. Landfill is the most common disposal option used in many Asian countries because it is inexpensive. In most countries and regions in Asia, plastics, glass, papers, and metal are collected by either informal workers or a municipality, and the materials are recycled. Many Asian countries and regions have introduced laws on municipal solid waste recently. However, major concern for waste management in Asian countries/region has addressed to quality control, i.e. environmental protection, compared to quantity control. It is a positive sign that the importance of the waste management hierarchy—that is, reduce, reuse, recycle ("3R"), and disposal—is gradually being recognized; the challenge now is to put it into practice effectively in the many different contexts found in Asia.

Keywords: Waste management, Municipal solid waste, MSW generation, Landfill, Recycling.

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1. Introduction

With the rapid economic growth and urbanization that is taking place in Asia, solid waste generation and management is becoming a major social and environmental issue. Complicating the picture, each country and region within Asia has its own background and characteristics in relation to solid waste management and material-cycles policy, even though they share the same global region.

According to the World Bank, the urban areas of Asia produce about 760,000 tons of MSW per day, and it is estimated that this figure will increase to 1.8 million tons of waste per day by 2025 (World Bank 1999). The data on solid waste management are often unreliable. There are only a few comparative studies for Asian countries/regions other than the World Bank survey, while comparative studies of Europe and the USA have been implemented by some researchers (for example, Sakai et al. 1996). Even though the existing data are potentially useful, the definitions or implications of some values are sometimes inconsistent, and this situation should be recognized.

This paper mainly focuses on the MSW, since there are a relatively satisfactory number of data available, compared with industrial waste. We compare and analyze the current status of waste management in Asia, especially MSW generation and disposal. Then we discuss waste management and recycling policy.

2. Current status of waste management in Asia

2.1. Waste generation and disposal

a. Definitions of *waste*

Solid waste is usually categorized into municipal solid waste (MSW) and industrial waste, according to its sources. When countries or regions have laws governing waste management, *solid waste* and *MSW* are usually given specific definitions. Table 1 shows the definitions of solid waste and MSW in selected Asian countries/regions. As can be seen, Indonesia, Malaysia, and Thailand have no laws on waste management, and they thus do not have official definitions of solid waste and MSW. India and Taiwan have definitions of MSW only.

The data in table 1 clearly show that the boundaries of MSW are not yet clear. The term is normally assumed to include all of the wastes generated in a community with the exception of solid wastes from industrial processes and agriculture (Tchobanoglous, Theisen, and Vigil 1983). In previous studies, it has included wastes generated from residences, commerce, institutions, construction, municipal services (Tchobanoglous, Theisen, and Vigil 1983), and sometimes even industrial sources (World Bank 1999). However, the precise definition varies greatly between studies and often only residential waste (or household waste) is included under MSW. From the authors' communication with experts in Asian countries/regions, construction wastes and any hazardous wastes are usually excluded in most countries. There is more complication regarding waste from industrial and institutional sources. In India, Republic of Korea, Turkey, Taiwan, and Japan, MSW includes part of the waste from industrial sources (the business sector), depending on waste types. In Hong Kong, industrial waste is officially included in

MSW. However, there is another notification that responsibility may be attributed to the generators, even though the waste is classified as MSW.

b. Waste generation

Estimated amounts of MSW and household waste generated in selected Asian countries are shown in table 2. It is true that the amount of household waste alone could be suitable for comparison and could avoid the distorting effect of including industrial wastes. However, exclusive household waste data exist for very few countries in Asia (the exclusive household waste data for China and Hong Kong Special Administrative Region are shown here for reference only). The proportion of household waste in MSW varies depending on the country. It is estimated as 60 to 70 percent in mainland China (Gao et al. 2002), 78 percent in Hong Kong (including commercial waste), 48 percent in the Philippines, and 37 percent in Japan (based on data from Osaka). According to the World Bank (1999), in high-income countries, only 25 to 35 percent of the overall waste stream is from residential sources.

Table 1a. Definitions of *solid waste* and *MSW* in each country/region

	China	Hong Kong	India	Indonesia	Republic of Korea	Malaysia
Definition of *solid waste*	Wastes in solid or semi-solid state generated in production, construction, daily life, and other activities, which might pollute the environment. (Law on the Prevention and Control of Solid Waste Pollution to the Environment, 1996).	Any substance or article which is abandoned and includes animal waste, chemical waste, household waste, livestock waste, street waste, and trade waste. (Waste Disposal Ordinance, 1991 amended).	–	–	Useless materials generate from human and business activities, such as refuse, burnable waste, sludge, waste oil, waste acid, waste alkaline, and dead animals. (Waste Management Law, 1991 amended)	–
Types of solid waste included	• MSW; • Industrial solid waste; • Construction and demolition waste; • Hazardous waste.	• MSW; • Construction and demolition waste; • Special waste (hazardous waste).	• MSW; • Hazardous waste; • Bio-medical waste.	• Hazardous and toxic waste.	• Household waste (MSW); • General industrial waste; • Construction and demolition waste; • Hazardous (designated) waste.	• Scheduled waste; • (Hazardous waste).
Definition of *MSW*	Solid wastes generated in the course of urban daily life or activities providing services for urban daily life as well as other solid wastes as stipulated by law and administrative regulations.	Solid waste from household, commercial, and industrial sources.	Commercial and residential wastes generated in a municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. (Municipal Solid Waste Regulation (Management and Handling), 2000).	–	Household waste (MSW) includes household waste and household-type industrial waste. Household waste is defined as waste other than industrial waste.	–

Table 1b. Definitions of *solid waste* and *MSW* in each country/region

	Philippines	Taiwan	Thailand	Turkey	Japan
Definition of *solid waste*	All discarded household, commercial wastes, non-hazardous institutional and industrial wastes, street sweepings, construction debris, agricultural wastes, and other non-hazardous/non-toxic solid wastes. (RA 9003 Ecological Solid Waste Management Act, 2001).	–	–	Materials unwanted by their producers, and may cause public nuisance or environmental pollution, and requiring proper disposal together with domestic wastewater treatment plant sludges.	Solid and liquid waste (or unwanted material) with no economic value (Waste Management Law, 1970)
Types of solid waste included.	See above.	• MSW • Industrial waste (Non-MSW).	• MSW; • Industrial waste (hazardous and non-hazardous).	• MSW; • Industrial waste.	• General waste (MSW) • Industrial waste • Specifically controlled general waste (hazardous general waste); Specifically controlled industrial waste. (Hazardous industrial waste).
Definition of *MSW*	–	Garbage, excrement and urine, animal corpses in solid or liquid form, generated by households or other non-industries, which have capacity to pollute the environment. (Waste Disposal Act, amended 2001).	–	Wastes originating from households that do not contain hazardous materials, and those collected from parks and recreational areas. Non-hazardous industrial and commercial wastes are also included.	MSW corresponds to *general waste*, which is defined as waste other than industrial waste. (*Industrial waste* is defined by waste types and sectors.)

Table 2. MSW and household waste generation in each country/region

	China	Hong Kong	India	Indonesia	Republic of Korea	Malaysia	Philippines	Taiwan	Thailand	Turkey	Japan
Year	2000	2003	2002	1995	2002	2002	2000	2002	2002	2001	2001
Population (million)	1,267.4	6.8	1,052.0	194.8	47.6	24.5	76.5	22.6	62.8	68.5	127.3
GDP per capita (current US$)	856	23,800	471	1,038	10,013	3,868	978	12,570	5,430	2,146	32,745
MSW generation (kilotons/year)	130,320	3,440[4]	–	–	18,189[7]	–	10,670[9]	7,970[10]	14,317[11]	25,100[12]	52,100[13]
MSW generation per capita (kg/capita-day)	1.70[1]	1.39	0.2–0.5[5]	0.76[6]	1.05	0.88–1.44[8]	0.5–0.7[9]	0.97	0.62	1.00	1.12
Household waste generation (kilotons/year)	78,192[3]	2,700[4]	–	–	–	–	–	–	–	–	–
Household waste generation per capita (kg/capita-day)	1.02 [3]	1.09	–	–	–	–	–	–	–	0.57	–

Notes and sources: 1. Ministry of Construction, China. 2. For the calculation, an urban population of 209.5 million was assumed. 3. 60 percent of MSW is assumed to be household waste, referring to Yang 2003. 4. Hong Kong Environmental Protection Department 2004. 5. Shekdar 2002a. 6. World Bank 1999. 7. Ministry of Environment.8. Idris, Inanc, and Hassan 2004. 9. World Bank 2001. 10. Lin 2003. 11. Vanapruk 2003. 12. Inanc et al. 2004. 13. Ministry of the Environment, Japan 2004.

MSW generation per capita, or unit generation of MSW, ranges between 0.5 and 1.4 kg/(capita-day) in each country/region except China. MSW generation data in China are hard to understand. According to Fang (1999), in recent times the average MSW generation is about 1.12 to 1.2 kg/(capita-day) in megacities (including the agricultural population living in the surrounding areas). On the other hand, Yang (2003) insists that urban (non-agricultural) population alone should be used for calculating MSW generation per capita. For this study, we derived 1.7 kg/(capita-day) from 130.32 million tons of MSW generation and 209.53 million persons of urban population. This value is higher than that for other Asian countries and depends on what is counted as urban population.

Generally, high-income countries have higher unit generation. In Japan, MSW generation per capita has stabilized at approximately 1.1 kg/(capita-day) since the end of the 1980s. Middle- and low-income countries produce smaller amounts of MSW—between 0.5 and 1.0 kg/(capita-day) in recent years.

Many previous studies indicate that as gross domestic product (GDP) (or gross national product (GNP)) per capita increases, per capita MSW generation also increases, and that MSW generation becomes saturated at high GDP (Bakkes et al. 2004; Nakagawa 2003; Tanaka et al. 2002; World Bank 1999). Bakkes et al. show a curve for MSW generation and give a formula:

MSW generation per capita = -28.2361/ (GDP per capita + 30) + 1.0496; $r^2 = 0.59$

Tanaka et al. (2002) and Yoshizawa et al. (2004) have analyzed data from Organisation for Economic Co-operation and Development (OECD) countries and have further categorized them into three groups according to the rate of MSW generation by per capita GDP: high-generation group (the USA, Australia, etc.), middle-generation group (many EU countries), and low-generation group (Sweden, Japan, etc.).

Nakagawa has analyzed waste generation data for Asian countries/regions and found a similar correlation between MSW generation per capita and GNP per capita. He points out that the curve in most Asian countries is higher than in Japan.

We utilized data for the West from literature (OECD 2002) as well as the above Asian data. A similar curve of MSW generation per capita and GDP per capita was drawn (shown in figure 1). We assumed exponential fitting and obtained the following regression formula:

MSW generation per capita = 0.7184 x GDP per capita exp 0.227; $r^2 = 0.51$

Three implications were drawn from this analysis. The first is the possibility that we could find a more definite relationship between MSW generation and GDP. According to the Japan International Cooperation Agency (1997), per capita MSW generation rates among high-, middle-, and low-income populations in the Philippines are 0.37–0.55, 0.37–0.60, and 0.62–0.90 kg/(capita-day) respectively. As can be seen in this example, MSW generation per capita seems to vary depending on the income level in developing countries. It is true that data availability is quite limited. However, when we used some local data for both MSW generation and GDP, instead of country data for developing Asian countries, a clearer relationship between MSW generation and GDP per capita could be observed.

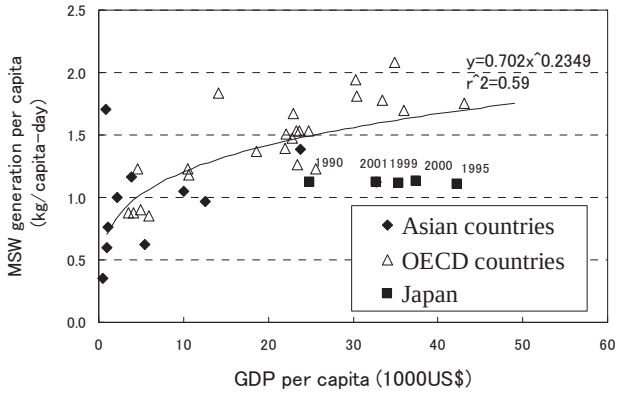


Figure 1. MSW generation and GDP per capita in Asia, OECD countries and Japan

Notes: Asian countries exclude Japan. OECD countries exclude the Republic of Korea, Turkey, and Japan. Data for Japan in 2001 was used for regression analysis together with others.

Sources: Asian countries: See table 2. OECD countries: OECD 2002. Japan: Ministry of the Environment, Japan 2004 and others.

The second implication concerns why MSW generation rises at low GDP levels. It can be easily understood that MSW per capita generation increases in developing countries and regions as GDP rises. However, it should also be noted that not all MSW is counted, due to the activities of the informal sector and self-disposal in developing countries. The informal sector contributes to waste reduction and recycling. However, the fact that the volume of waste collected by the informal sector is not usually counted in official statistics for waste generation is often overlooked. In addition, collection rates are low in developing countries; for example, 72.5 percent in urban areas of India, 70 percent in Malaysia, 70–80 percent in Thailand (Inanc et al. 2004), and 70 percent in urban areas and 40 percent in rural areas of the Philippines (World Bank 2001a). In those countries, it is expected that collection rates and MSW generation will increase in the near future, since municipal collection services will be better organized as the economies grow.

The third implication relates to the MSW generation rates at relatively high GDP levels. When waste generation reaches saturation point at high GDP, it is a flat line and far from the Kuznet's curve that is often postulated for the relationship between economic growth and other environmental issues (Harashima and Shimazaki 2002; Selden and Song 1994). Matsuoka, Matsumoto, and Kochi (1998) suggest that the environmental Kuznet's curve can hardly be observed other than for sulfur oxides emissions. Our study certainly suggests that this curve may not be applied to the case of MSW generation. However, different levels of MSW generation per capita can be found for high-GDP countries, and Japan might provide a successful case for de-coupling economic growth and MSW generation. Japan in 2000 introduced the new concept of a sound-material-cycle society. All high-income countries should make efforts to decrease MSW generation by following the concepts of the sound-material-cycle society or "3R" (reduce, reuse, recycle).

c. Waste composition

Data for composition of MSW cannot easily be obtained at national level, although such data are often collected by some municipalities or by researchers. Organic matter is the main component of MSW in Asia, as shown in figure 2. That proportion ranges 34 percent even to 70 percent, which is higher than the 20–50 percent of most European countries (OECD 2002).

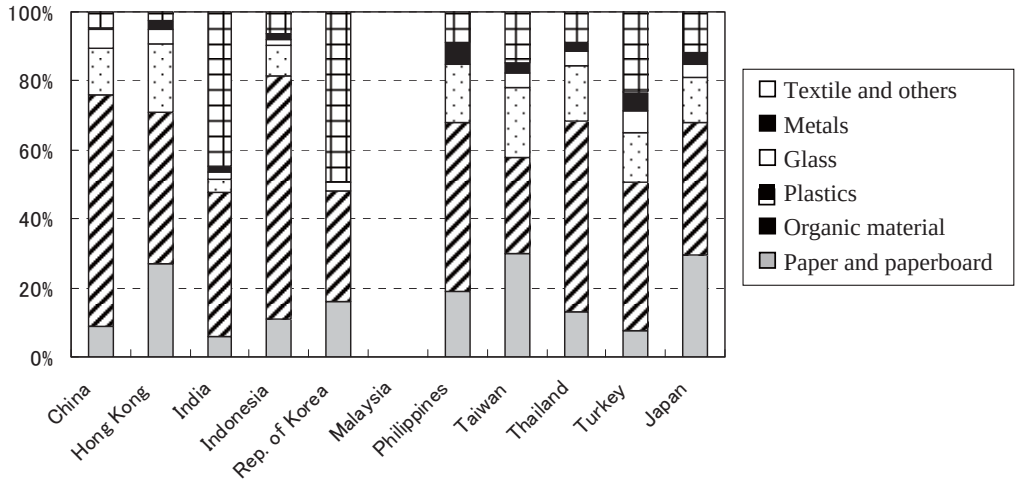


Figure 2. Composition of MSW in Asian countries/regions

Note: China (1998): Data for Shanghai from Zhang and Yang 2002. Hong Kong (2003): Hong Kong Environmental Protection Department 2004. India (1995): TERI 2000—national average data. Indonesia (1993): Data for Surabaya city in rainy season from Ishii and Watanabe 1996. Republic of Korea (2002): Ministry of Environment. Plastics are included in "textile and others". Philippines (1999): World Bank 2001a. Taiwan (2002): Lin 2003. Thailand (2001): Data for Bangkok from Vanapruk 2003. Turkey (2000): Data from Istanbul Greater City Municipality 2000. Japan (2001): Average data for six cities from Japan Environmental Sanitation Center 2001. Malaysia: No data.

In recent times, more and more plastic and paper waste is being generated in every country/region of Asia, reflecting changing lifestyles. In Taiwan and Japan, already as much as 30 percent of total MSW is wastepaper. According to the World Bank (1999), other high-income countries also have a large proportion of paper in their waste.

Some countries have their own peculiarities in composition of MSW. For example, a large amount of ash is generated from domestic coal used for heating in northern cities of China and Turkey.

As described in the previous section, the informal sector plays important roles in collecting recyclable materials in developing countries such as China, India, the Philippines, and Turkey. It is difficult to know the amounts of materials collected and recycled by the informal sector, and how much is thus absent from official waste composition data; it is simply assumed that the overall volumes collected by the informal sector are about 10 to 15 percent in China (Yang 2003) and 15 to 20 percent in India (Shekdar 2002b).

2.2. Waste disposal

Landfilling is the major method of disposal in many Asian countries, as can be seen in figure 3. This is mainly because it is, usually, inexpensive. Especially in China and India, the landfill rate reaches more than 90 percent.

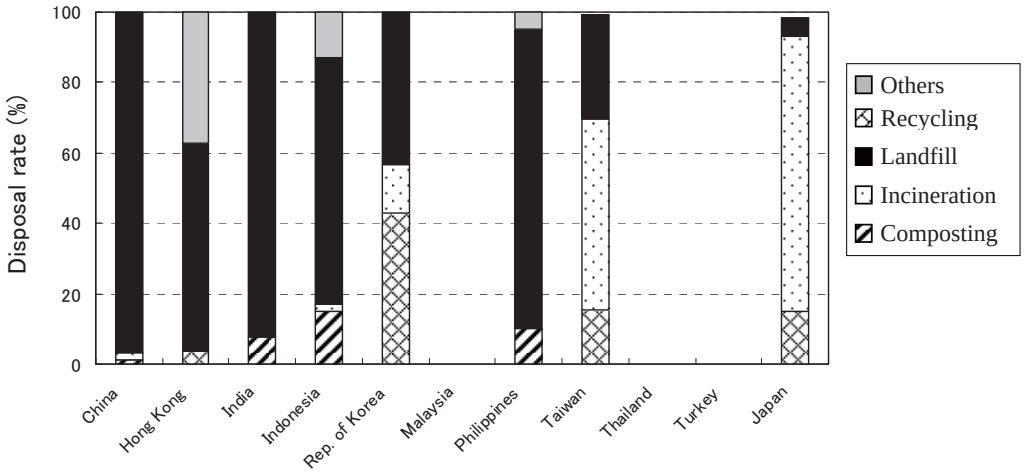


Figure 3. MSW disposal in Asian countries/regions

Note: China (2000): Survey of 138 cities by Gao et al. (2002). Hong Kong (2003): Hong Kong Environmental Protection Department 2004— "others" implies export for recycling. India (1999): Data for Delhi from TERI 2000. Indonesia (1997): World Bank 2001b—data do not include recycling. Republic of Korea (2001): Ministry of Environment—data do not include recycling. Philippines (1997): World Bank 2001a—data do not include recycling. Taiwan (2002): Lin 2003—"recycling" includes composting. Turkey: No data (Turkey has no incinerators for MSW and most landfill sites for MSW were open dumps by 1991, according to Inanc 2003). Japan (2001): Ministry of the Environment, Japan 2004. Malaysia, Thailand: No data.

The concept of landfill quality development in Asia was introduced by Tanaka et al. (2002). They classified landfill into three levels: open dumping, semi-sanitary landfill (which is covered only), and sanitary landfill (which is covered and leachate treated). Tanaka, Tojo, and Matsuto (2003) examined the development of landfill technologies using the case of Japan from 1976 to 1995.

Data for landfill in Asian countries/region are quite limited. However, Inanc et al. (2004) gathered available landfill information from each country/region in Asia in a comparative format, including landfill classification and numbers. Idris, Inanc, and Hassan (2004) provide the example of the detailed landfill classification system used in Malaysia.

Referring the landfill classification by Tanaka et al. (2002) and the database provided by Inanc et al. (2004), we have shown the relationship between GDP and landfill quality levels (figures 4(a) and 4(b)). This shows that sanitary landfill sites are very limited and open dumping can be easily found in developing countries. However, various efforts have been made to improve the quality of landfill sites. For example, many municipalities stopped open dumping in Turkey in 1991 (Inanc 2003), and in India, landfilling is restricted to non-biodegradable, inert waste and other wastes that are not suitable for

recycling. In the Philippines, RA9003 (see table 3(2)) recommended local government units to convert existing open dumps into controlled dumps and further into sanitary landfill (Magalang 2003).

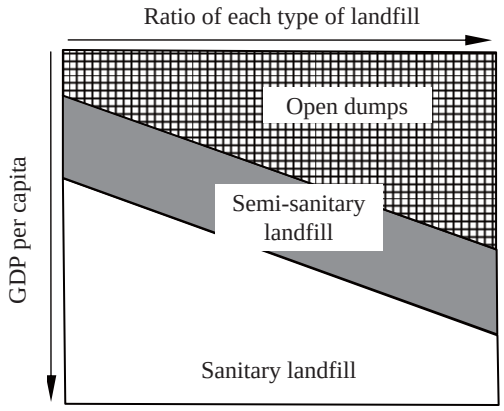


Figure 4a. Development of landfill levels (overall trend)

Incineration involves high costs for construction and operation of facilities. In Japan, incineration has been regarded as important for waste disposal from the point of view of public health. For the last 10 years, the percentage of incinerated waste in the total amount of MSW in Japan has leveled off at 73–78 percent. Besides Japan, the Republic of Korea and Taiwan have been increasingly using incineration since the late 1990s. Incineration is not well accepted in other countries because of its cost. Moreover, the Philippines banned the incineration of MSW, medical waste, and hazardous waste under the Clean Air Act of 1999, RA8749.

Composting can be a major disposal method for organic matter. In India, Indonesia and the Philippines, around 10 percent of generated waste is composted (TERI 2000, World Bank 2001a and 2001b). Manual methods of composting are still used in many towns in India; although mechanical composting plants have been built recently at a number of place in India through private-sector participation, the capital investment and recurring expenditure are high (Shekdar 2002b).

2.3. Recycling

Every country/region recognizes the importance of recycling. In the case of MSW, there are two main recycling flows. In the first flow, recyclable materials are collected at sources by collectors, including those in the informal sector. In the second flow, these materials are separated and recycled by the municipality after MSW collection. As long as the materials have a certain economic value, they are likely to be collected by the informal sector.

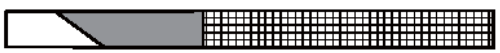
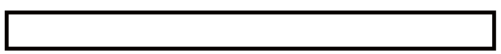
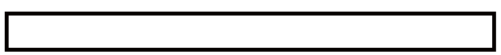
Proportions of open dumps, simple landfill, and sanitary landfill	GDP per capita (current US$)	Country	Remarks
	471	India	All waste disposal sites are open dumps (Damodaran et al. 2003).
	856	China	More than 80% of landfills are simple landfill sites (Tsinghua University 2002).
	978	Philippines	721 open dumps (92%), 65 controlled dumps (that seem to be regarded as semi-sanitary landfills, 8%). Proposed new sites are all controlled dumps or sanitary landfills (Inanc et al. 2004).
	2,146	Turkey	Majority of the disposal sites in small cities and rural areas are open dumps. 12 sanitary landfills accept 33% of total MSW generated nationwide in 2001 (Inanc et al. 2004).
	3,868	Malaysia	60% open dumps, managed poorly.
	12,570	Taiwan	Remediation of 60% of dumps before 2004 is planned. (Inanc et al. 2004).
	23,800	Hong Kong	All sanitary landfill.
	32,745	Japan	All sanitary landfill.

Figure 4b. Development of landfill levels (actual example)

Sources: India: Damodaran et al. 2003. China: Tsinghua Universty 2002. Philippines, Turkey, Taiwan: Inanc et al 2004.

In most countries/regions, plastics, glass, papers, and metals are well collected by either the informal sector or municipalities, and these materials are recycled. Nevertheless, very few countries or regions hold data on recycling rates for each type of material, except for Hong Kong, the Republic of Korea, Turkey, and Japan. The recycling rates for typical materials from MSW in these countries are shown in figure 5.

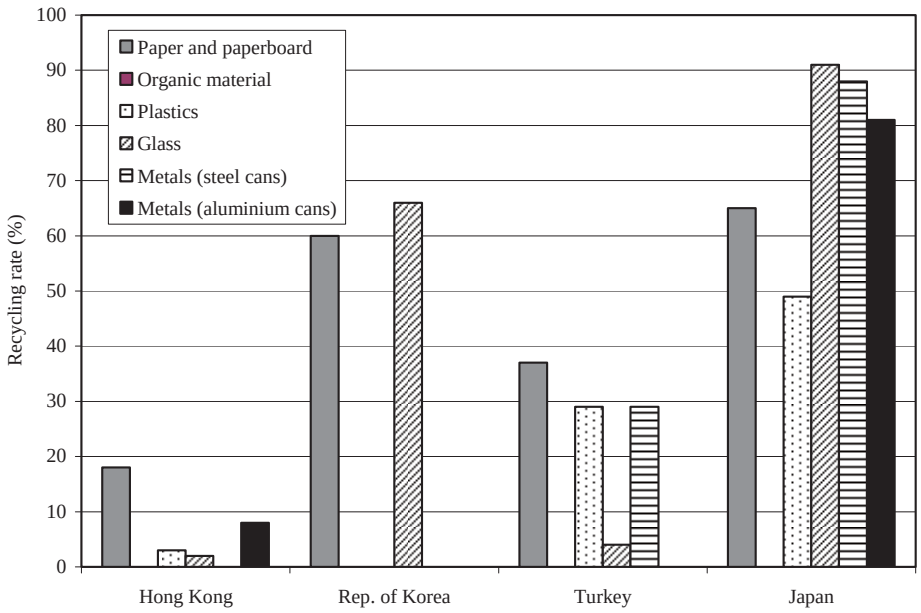


Figure 5. Recycling rate of each materials from MSW in Asian countries/regions

Note: Hong Kong (2003): Hong Kong Environmental Protection Department 2004—only domestic recycling (not export for recycling) is counted. Republic of Korea (2000): Data from OECD 2002. Turkey (2000): Data from Metin et al. 2002. Japan (2003): Data from Clean Japan Center 2002 and others—recovery rate shown for paper and paperboard. "Plastic" means polyethylene terephthalate (PET) bottles here. No data were available for China, India, Indonesia, Malaysia, Philippines, Taiwan, or Thailand.

2.4. Waste management costs

Collection costs generally make up the dominant part of all waste management costs in those countries/regions where landfill is a major disposal method, including the Republic of Korea. In India, nearly 90 percent of total waste management costs go on manpower, mostly in collection. On the other hand, in Japan, a large portion of budget is spent on incineration, and the cost of this doubled between 1987 and 1993.

3. Policy and regulation of waste management and recycling in Asia

Table 3 summarizes legislation and policy on waste management and material cycles in each country/region.

Table 3a. Legislation and policy on waste management and material cycles in Asia

	China	Hong Kong	India	Indonesia	Republic of Korea	Malaysia
Legislation	• Law on the Prevention and Control of Solid Waste Pollution to the Environment (1996). • Temporary Provisions on Some Issues in Implementing Comprehensive Utilization of Resources (1985, 1996 amended). • The tenth Five-year Plan for Renewable Resources Recovery and Reuse (2001).	• Waste Disposal Ordinance (1980, amended 2004).	• Municipal Solid Waste Regulation (Management and Handling) (2000).	• Act no. 23/1997 on Environmental Management.	• Waste Management Law (1986, amended 1999). • Resources Conservation and Recycling Promotion Law (1992, amended 2003). • National Comprehensive Waste Management Plan (1993).	• Environmental Quality Act (1974, amended 2001). • Environmental Quality (Scheduled Wastes) Regulations (1989).
Basic goals or standards	Waste reduction and minimization of solid waste output, and comprehensive utilization of resources.	Unclear.	Minimization of the burden of landfills is addressed in the Regulation.	Indonesian Agenda 21 (management of waste and emissions, including management of hazardous waste, management of solid and liquid waste, and management of radioactive waste).	The goal "firm establishment of a sustainable and resource circulating socio-economic foundation" is given in the National Comprehensive Waste Management Plan.	Waste minimization is prescribed the in Environmental Quality Regulations (only for hazardous waste).

Table 3b. Legislation and policy on waste management and material cycles in Asia

	Philippines	Taiwan	Thailand	Turkey	Japan
Legislation	RA9003 Ecological Solid Waste Management Act (2001)	Waste Disposal Act (1974, amended 2001) Resource Recycling and Reuse Act (2002)	Enhancement and Conservation of National Environmental Quality Act, B.E.2535 (1992)	Solid Waste Control Regulation (1991)	Basic Law for Establishing a Sound Material Cycle Society (2000) Waste Management Law (1970, 2000 amended) Law for the Promotion of Utilization of Recycled Resources (2000 amended)
Basic goals or standards	RA9003 sets targets for solid waste avoidance and volume reduction.	Avoidance or reduction, recycling, and disposal.	MSW generation per capita, non-collection rate, recycling rate, etc. are set as standard for 2005 to 2010.	Preventing damage to the environment during solid waste generation, transportation, and disposal. Waste minimization, proper disposal and more recycling/recovery.	Productivity per resources use, recycling rate, and final disposal volume are main standards under the Basic Plan for a Recycling-based Society. Individual recycling laws each set target recycling rates .

Many Asian countries/regions have already introduced laws on MSW. In China, Japan, the Republic of Korea, and Taiwan, legislation on MSW was promoted relatively early. Indonesia, Malaysia, and Thailand control hazardous waste only under toxic substances regulations, but do not have waste management laws. This may imply that waste management is of higher concern in Asian countries/regions in terms of quality control—that is, environmental protection—compared to quantity control. Appropriate management of solid waste, especially hazardous waste, has high priority in most countries/regions.

The Incineration Ban, based on the Clean Air Act, in the Philippines is also notable, although it targets medical (hazardous) waste as well as MSW.

3.1. Material-cycle control

More and more countries/regions in Asia recognize the need for quantity management due to limitations of space for landfill and treatment capacity. Only a few countries and regions have a concrete index for remaining potential landfill capacity, including Japan and Hong Kong, where the remaining landfill capacity is reported as 12.5 years (from FY2001, Ministry of the Environment, Japan 2004) and 10 years (from 2000, Hong Kong 2001) respectively. However, the importance of the waste management hierarchy—that is, 3R and disposal—is gradually being recognized throughout Asia.

The Republic of Korea and Japan are two active countries that implement measures to support material-cycles policy beyond the framework of mere waste management. In Japan, the Fundamental Law for Establishing a Sound Material Cycle Society was enacted in 2000, and targets were set for material flow in terms of resource productivity, cyclical use rate, and final disposal amount. Material flow analysis at national level in Japan is conducted by Moriguchi (2000) in collaboration with European countries and the United States, and the results are referenced in the national White Paper on the Environment. It shows that a total of about 1,900 million tons of new materials entered the Japanese economy in FY2000 and approximately 1,100 million tons remains in the anthroposphere, adding to stocks (Ministry of the Environment of Japan 2003).

The Republic of Korea explicitly prescribes the “Extended Producer Recycling” (EPR) system under the Resources Conservation and Recycling Promotion Law, amended in 2003. Another remarkable characteristic of the Korean approach is that the new law abolished the deposit system and introduced the “Producer Responsible Recycling” system.

Other countries are now promoting the activities to introduce laws and policies for promoting material cycles. China is preparing the Law for Promoting Circular Economy. In India and the Philippines, laws on the management of MSW have been enacted recently and the importance of material cycles is clearly mentioned in the laws.

3.2. Recycling and management of individual products

As table 4 shows, various regulations on the recycling or management of selected individual products such as packaging waste, E-waste (electrical appliances and personal computers), and End-of-Life Vehicles (ELV), have been enacted or are being prepared in many countries/regions of Asia.

Table 4a. Legislation and polices on various waste products in Asia

	China	Hong Kong	India	Indonesia	Republic of Korea	Malaysia
Packaging waste	–	Unclear.	Governmental ban on thin plastic bags.	–	Use of packaging and disposables is controlled. Four packaging materials (paper packs, metal cans, glass bottles, and plastic) are designated as "obliged recycling items".	–
E-waste (electrical appliances and personal computers)	Small-scale recycling business is eliminated by the e-waste import license system. An Electric Appliances Recycling Regulation was proposed in 2004.	Smuggling of e-waste is strictly controlled.	Batteries (Management and Handling Rules, 2001).	–	Electrical good are designated as "obliged recycling items".	–
ELVs	–	–	–	–	Car tires, lubricants, and batteries are designated as "obliged recycling items".	–

Table 4b. Legislation and polices on various waste products in Asia

	Philippines	Taiwan	Thailand	Turkey	Japan
Packaging	–	Free distribution of plastic bags is prohibited. (2003)	–	Solid Waste Control Regulation concentrates on the quota-deposit system about recovery of packaging waste.	The Packaging Recycling Law came into force in 1996. It contributes to recycling, but the participation of municipalities is limited.
E-waste (electrical appliances and computers)	–	E-waste is prescribed as "due-recycled waste" under the Waste Disposal Act.	–	–	The Home Appliances Recycling Law came into force in 2001. It caused a slight rise in illegal dumping. The way of charging recycling costs to the end-users at the recovery stage is still being. The Law for the Promotion of Utilization of Recycled Resources has been applicable to home and business PCs since 2003.
ELVs	–	ELVs are prescribed as "due-recycled waste" under the Waste Disposal Act.	–	–	The ELV Recycling Law comes into force in 2005. Producers are obliged to recycle ASR, CFCs, and airbags.

While Japan has many recycling laws governing each product, the Republic of Korea seems to cover all items under the one Resources Conservation and Recycling Promotion Law (the Recycling Law) and its EPR system. Also, the Republic of Korea and Taiwan both use strong terms, that is, “obliged recycling items” and “due recycled waste” respectively. They designate packaging waste, E-waste, and others as “wastes to be recycled” from the viewpoint of pollution prevention.

With regard to packaging waste, there are various bans or restrictions on the use of plastic bags in India, the Republic of Korea, and Taiwan. Such strong and direct control is evidence that many countries/regions have a great deal of trouble with disposable packaging in their waste management systems.

As for E-waste, responsibility for recovery and recycling is on producers under the EPR system in the Republic of Korea. In Japan, under the Home Appliances Recycling Law, producers are obliged to recover and recycle their products, and consumers pay the recycling costs.

The ELV Recycling Law of Japan, which comes into force in 2005, prescribes that when automobiles are discarded, the manufacturers are required to accept CFCs, airbags, and Automobile Shredder Residue (ASR) from the disposed automobiles and to recycle them appropriately, and that consumers are obliged to bear the expenses. Other Asian countries/regions have focused on new regulation for E-waste rather than ELV. This might imply that old vehicles are generally valuable and reused again and again in many Asian countries/regions.

ELVs and E-waste both contain hazardous substances like heavy metals. In order to prevent these leaking into the environment at small recyclers in developing countries, and to control the cycles of those materials, Asian countries should share necessary measures.

4. Concluding remarks

Every Asian country/region has a different background and characteristics in relation to material cycles and waste management policy. The data are often unreliable and thus difficult to share and compare. However, most countries/regions have common targets of implementing 3R and some countries are following the new concept of the sound material-cycle society. In addition, accelerating transboundary shipment of secondary materials (Terazono et al. 2004) requires cooperative measures and communication among countries. The tasks ahead of us demand the efficient utilization not only of resources but also of our intelligence in Asia.

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