What a Waste:

Solid Waste Management in Asia

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WHAT A WASTE:

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Recommendations and Conclusions

- Solid waste data is largely unreliable. This report contains one of the most comprehensive compilations of municipal solid waste data in Asia; yet, due to inconsistencies in data recording, definitions, collection methods, and seasonal variations, the data can only be considered approximate, albeit more accurate than most. For planning purposes, however, the data presented in this report should be sufficient.
- The urban areas of Asia now spend about US$25 billion on solid waste management per year; this figure will increase to at least US$50 billion in 2025. Today's daily waste generation rate is about 760,000 tonnes. By 2025, this rate will be increased to about 1.8 million tonnes per day.
- Japan spends about ten times more for waste disposal than collection costs (mostly incineration costs). Total waste management costs in low income countries are usually more than 80 percent for collection costs. Lower cost landfilling is usually a more practical waste disposal option than incineration.
- Municipal governments are usually the responsible agency for solid waste collection and disposal, but the magnitude of the problem is well beyond the ability of any municipal government. They need help. In addition to other levels of government, businesses and the general community need to be more involved in waste management.
- Generally, solid waste planners place too much emphasis on residential waste; this waste represents only about 30 percent of the overall municipal waste stream but often receives the lion's share of attention.
- The waste components requiring priority attention in Asia are organics and paper.
- Indonesia and the Philippines as well as parts of China and India are the Asian countries facing the greatest waste management challenge, based on projected waste generation rates and relative affluence to deal with the problem.

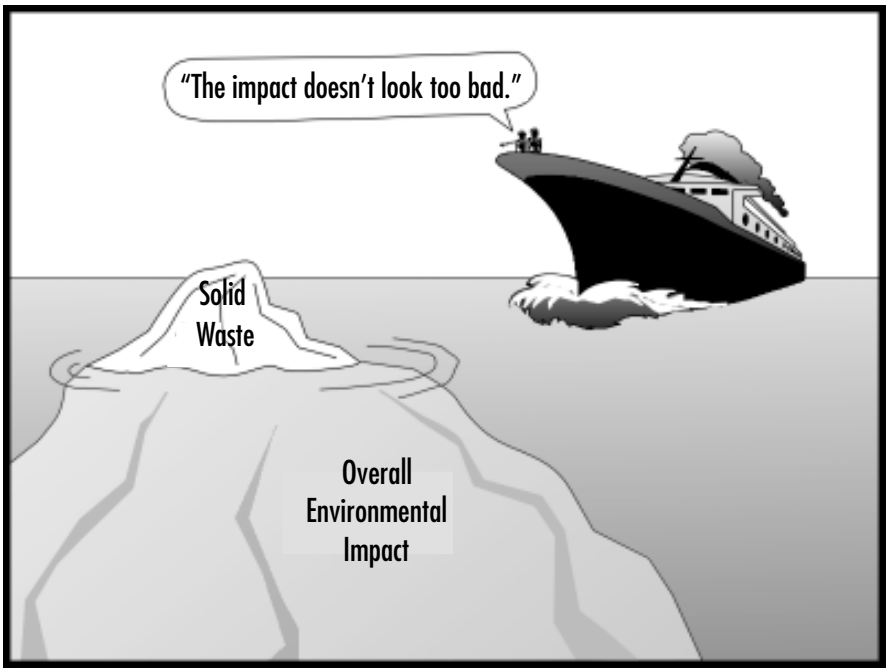
The urban areas of Asia now spend about US$25 billion on solid waste management per year; this figure will increase to about US$47 billion in 2025.

- In terms of waste management trends, no region of the world faces a greater need to break the inextricable link between waste generation rates and affluence than Asia. For example, if Asia follows life style trends of the US and Canada (as Hong Kong already seems to be doing) versus the more typical European urban resident, the world would need to supply about 500 million tonnes more resources in 2025.
- Asia should pursue regional approaches to many solid waste management problems, e.g., packaging regulations and import/export rules.
- Urban residents generate two to three times more solid waste than their fellow rural citizens.
- Municipalities should charge for waste disposal, and possibly collection, based on generation rates.
- Industrialized countries contain 16 percent of the world's population but use about 75 percent of the world's paper supply. Residents of India, Indonesia, and China, for example, are aspiring to be as affluent as more industrialized nations. This would require a doubling of the world's current level of paper production.

1. INTRODUCTION: SOLID WASTE MANAGEMENT IN ASIA

As urbanization and economic development increases in Asia, nowhere is the impact more obvious than in society's "detritus," or solid waste. Today, the urban areas of Asia produce about 760,000 tonnes of municipal solid waste (MSW) per day, or approximately 2.7 million m^3 per day. In 2025, this figure will increase to 1.8 million tonnes of waste per day, or 5.2 million m^3 per day. These estimates are conservative; the real values are probably more than double this amount.

Local governments in Asia currently spend about US $25 billion per year on urban solid waste management. This amount is used to collect more than 90 percent of the waste in high income countries, between 50 to 80 percent in middle income countries, and only 30 to 60 percent in low income countries. In 2025, Asian governments should anticipate spending at least double this amount (in 1998 US dollars) on solid waste management activities.



To carry out integrated solid waste management, local governments need partners. National governments must reduce the externalities of waste by considering measures such as full cost accounting, package deposits, manufacturer responsibility, and extended product care. The general community, which is probably the most important stakeholder in waste management activities, must also actively participate in the solutions by modifying their behavior patterns. For example, they need to exert discipline in separating waste, using containers in a beneficial way, and exercising environmentally friendly purchasing habits.

This paper reviews the broad trends related to solid waste management in Asia[1]. "The big picture" projects regional urban MSW quantities and compositions in 2025. The forces of these trends are analyzed, and preliminary suggestions for reducing the impact of these trends are provided. The paper also briefly discusses possible policies and budget requirements for dealing with this burgeoning waste stream.

This paper contains one of the most comprehensive collections of solid waste generation data. In compiling these data, the authors identified shortcomings with terminology used and sampling methods and built-in problems with consistency. In Annex 1, recommendations are made to help overcome these limitations and for improving solid waste data collection and presentation. Annex 2 presents waste generation rates for selected Asian cities.

It is beyond the scope of this paper to venture into the debate on "the limits to growth" vis-a-vis resource consumption or the negative environmental impacts that will occur from wastes generated by an increasingly consumeristic one billion urban Asians. The fear about these effects, however, is warranted, particularly since nearly 95 percent of environmental damage occurs before a product is discarded as

[1] Asia in this report is limited to China, Japan, Hong Kong, Republic of Korea, Mongolia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam, Bangladesh, India, Nepal, and Sri Lanka.

solid waste. This paper discusses the concern about environmental effects associated with solid waste management as well as the escalating costs that solid waste management consumes from local government budgets and how to handle these increases.

This paper focuses on waste management only as it pertains to urban environments, based on (1) projections that in 2025 about 52 percent of Asia's population will reside in urban areas, and (2) evidence that urban residents generate at least two times more waste per capita than their rural counterparts. Although urban waste management data may be inconsistent and unreliable, rural solid waste management data are virtually nonexistent and are derived only from assumptions regarding purchasing habits. Given these factors, it is clear that solid waste management efforts must target priority urban areas.

This paper does not review "where the waste goes." A follow-up study that reviews composting rates (existing and potential), recycling (existing programs, potential markets), number and working conditions of waste pickers, would be a valuable contribution to municipal waste management planning.

2. Waste Characterization

Solid waste streams should be characterized by their sources, by the types of wastes produced, as well as by generation rates and composition. Accurate information in these three areas is necessary in order to monitor and control existing waste management systems and to make regulatory, financial, and institutional decisions.

Annex 1 discusses in detail reliability issues and compositions of waste data. Better consistency in definition and methodology is needed. Although this paper contains one of the most comprehensive compilations of MSW data for Asia, readers must exercise caution in interpretating the data. Severe under-recording of waste quantities is typical, and total waste generation is usually much higher than that reported by government agencies.

One important observation shown in Annex 1 is that apart from localized anomalies, such as the use of coal for cooking and heating, urban waste generation rates are generally consistent vis-a-vis local economic activity and residential wealth. Because waste characterization studies are relatively expensive to conduct, the general "rules of thumb" provided in this paper should provide sufficient direction for the purposes of waste management planning.

In the context of this paper, waste is defined as any unwanted material intentionally thrown away for disposal. However, certain wastes may eventually become resources valuable to others once they are removed from the waste stream. This definition of waste may differ somewhat from definitions used by other international data sources.

Knowledge of the sources and types of waste in an area is required in order to design and operate appropriate solid waste management systems. (See Figure 1.) There are eight major classifications of solid waste generators: residential, industrial, commercial, institutional, construction and demolition, municipal services, process, and agricultural.

MSW includes wastes generated from residential, commercial, industrial, institutional, construction, demolition, process, and municipal services. However, this definition varies greatly among waste studies, and some sources are commonly excluded, such as industrial, construction and demolition, and municipal services. Often only residential waste is referred to as MSW, and in high income countries, only 25 percent to 35 percent of the overall waste stream is from residential sources[2]. It is important to define the composition of the municipal waste stream in a clear and consistent fashion. For example, if this municipal waste stream includes construction and demolition waste, the quantity of waste is doubled. Far too often,

[2] Personal Communication: Region of Vancouver, 25 percent residential (Linda Shore); Copenhagen, 30 percent residential (Helmer Olsen); Toronto, 35 percent residential (excluding construction and demolition - Tim Michael); Osaka, 37 percent residential (excluding industrial waste - Mr. Sawachi).

waste management decisions are based disproportionately on residential waste, which accounts for an increasingly small fraction of the waste stream as an area industrializes.

2.1 Waste Generation Rates

Waste generation rates are affected by socioeconomic development, degree of industrialization, and climate. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of solid waste produced. Figure 2 gives urban MSW generation rates, as a weighted average of the waste data available from various cities. Waste generation rates for various Asian cities are in Annex 2.

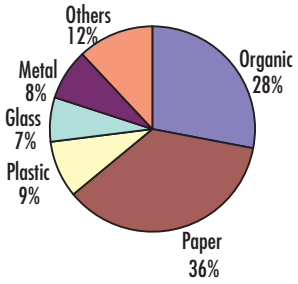
Figure 1: Sources and Types of Solid Wastes

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, hospitals, prisons, government centers	Same as commercial
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off-specification products, slag, tailings
All of the above should be included as "municipal solid waste."		
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides)

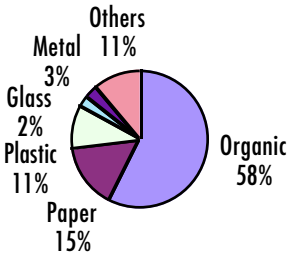
Figure 2: Waste Composition of Low, Middle, and High Income Countries

Current Waste Quantities and Composition

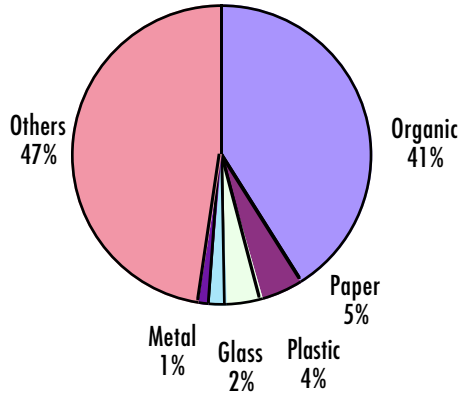
High Income Countries: Current
Total waste = 85,000,000 tonnes per year



Middle Income Countries: Current
Total waste=34,000,000 tonnes per year

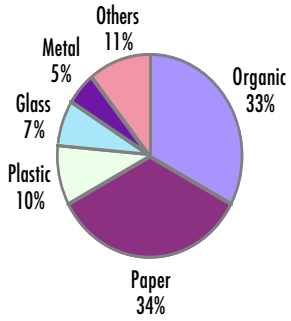


Low Income Countries: Current
Total waste=158,000,000 tonnes per year

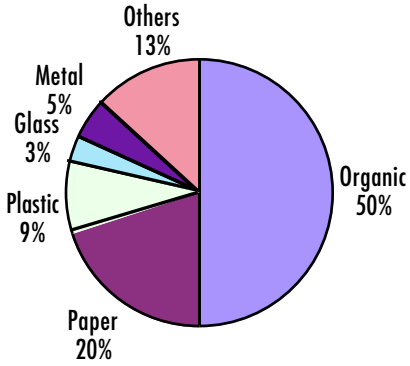


2025 Waste Quantities and Composition

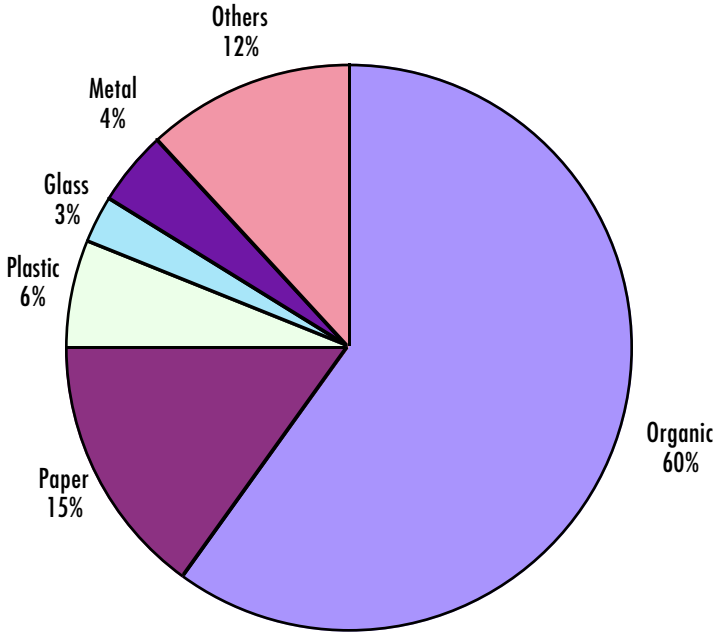
High Income Countries: Year 2025
Total waste=86,000,000 tonnes per year



Middle Income Countries: Year 2025
Total waste=111,000,000 tonnes per year



Low Income Countries: Year 2025
Total waste=480,000,000 tonnes per year



Note: Approximate scale only.

Low income countries have the lowest percentage of urban populations and the lowest waste generation rates, ranging between 0.4 to 0.9 kg per capita per day. All of the countries that have a GNP per capita less than US $400 produce under 0.7 kg per capita per day. As GNP increases toward the middle income range, the per capita waste generation rates also increase, ranging from 0.5 to 1.1 kg per day. As predicted, the high income countries show the greatest generation rates, which vary from 1.1 to 5.07 kg per capita per day.

Figure 3: Current Urban Municipal Solid Waste Generation

Country	GNP Per Capita [1] (1995 US $)	Current Urban Population (% of Total)[2]	Current Urban MSW Generation (kg/capita/day)
Low Income	**490**	**27.8**	**0.64**
Nepal	200	13.7	0.50
Bangladesh	240	18.3	0.49
Myanmar	240*	26.2	0.45
Vietnam	240	20.8	0.55
Mongolia	310	60.9	0.60
India	340	26.8	0.46
Lao PDR	350	21.7	0.69
China	620	30.3	0.79
Sri Lanka	700	22.4	0.89
Middle Income	**1,410**	**37.6**	**0.73**
Indonesia	980	35.4	0.76
Philippines	1,050	54.2	0.52
Thailand	2,740	20.0	1.10
Malaysia	3,890	53.7	0.81
High Income	**30,990**	**79.5**	**1.64**
Korea, Republic of	9,700	81.3	1.59
Hong Kong	22,990	95.0	5.07
Singapore	26,730	100	1.10
Japan	39,640	77.6	1.47

[1]World Bank, 1997b
[2]United Nations, 1995
*estimated GNP

See Figure 7 for comparison to 2025.

Hong Kong generates enormous quantities of construction and demolition waste, which explains their exceptionally high per capita MSW generation rate in comparison to other countries. Hong Kong's waste generation rate better reflects the true quantities of waste produced by all activities within the municipality than some of the other countries. Although Singapore and Japan report significantly lower generation rates than other high and middle income countries, the figures for these countries do not represent all municipal solid wastes. The Singapore generation rate considers only residential wastes, whereas the Japanese data include only wastes produced from households and general wastes from business activities. For both countries, total waste quantities would be much higher if industrial, commercial, institutional, construction and demolition, and municipal services wastes were also included.

Comparing generation rates for various countries is problematic. As demonstrated by Hong Kong, Singapore, and Japan, global inconsistencies in the way municipal solid waste is defined and quantified can lead to significant differences among the "official" waste generation rates.

As mentioned previously, very little information about rural waste generation rates in Asian countries is available; however, one can assume that rural populations will generate less waste because these areas have lower per capita incomes. Urbanization and rising incomes, which lead to more use of resources and therefore more waste, are the two most important trends that factor into rising waste generation rates. Figure 4 exemplifies this trend. Individuals living in Indian urban areas use nearly twice as many resources per capita than those living in a rural setting. Because they consume and generate more solid

waste, the Indian urban population is expected to produce far more waste per capita than its rural population. This difference between rural and urban waste generation rates also exists in other Asian countries, such as in Bangladesh, where the rural population generates only 0.15 kg per capita per day, while their urban counterparts generate 0.4 to 0.5 kg per capita per day (World Bank, 1998a).

2.2 Waste Composition

Waste composition is also influenced by external factors, such as geographical location, the population's standard of living, energy source, and weather. Figure 3 presents the current average urban waste compositions for low, middle, and high income Asian countries. The percentages are based on a weighted average of the compositions for individual countries, which are located in Annex 2. Although the definitions and methodologies for determining composition were rarely discussed in waste studies, the compositions for municipal solid waste are assumed to be based on wet weight.

Generally, all low and middle income countries have a high percentage of compostable organic matter in the urban waste stream, ranging from 40 to 85 percent of the total. China and India diverge from this trend because they traditionally use coal as a household fuel source. The ash that is subsequently produced is very dense and tends to dominate the waste stream in terms of weight. Ash is included in the "others" category and makes up 45 and 54 percent of India and China's waste composition, respectively. Figure 5 shows the degree to which the preference of coal over gas in a Chinese city increases the percentage of inorganics in the waste stream. This increase obviously has considerable implications for these countries as income levels increase.

Figure 2 shows that the compostable fraction in high income countries, which ranges between 25 and 45 percent, is significantly lower than for low and

Figure 4: Direct and Indirect Per Capita Consumption in India, 1989—90, Rupees/annum

Commodities	Rural per capita consumption	Urban per capita consumption
Sugarcane	84.34	79.34
Cotton	58.34	94.00
Coal and lignite	33.73	81.69
Crude petroleum and natural gas	60.34	162.03
Iron ore	0.37	0.81
Other metallic minerals	2.23	5.23
Cement	4.08	7.88
Iron and steel	43.15	95.48
Electricity, gas, and water supply	121.53	296.69
All commodities	4996.95	9720.20
Population (in millions)	606.6	204.6
Percentage of population	74.8	25.2

(Parikh et al., 1991. Cited in Hammond, 1998)

Figure 5: Waste Composition Among Different Types of Households in Dalian, China

Households Type	Waste Content Percentage			
	Percentage	Organic	Inorganic	Other
Cooking with gas Individual heating with coal	35.3	70.1	19.3	10.6
Cooking with coal Central heating with coal	46.5	66.6	25.5	7.9
Cooking with coal Individual heating with coal	18.2	38.3	60	2.7

(Dalian Environment and Sanitation Department (DESMB), 1990. Cited in Ecology and Environment, Inc., 1993)

middle income countries. The percentage of consumer packaging wastes increases relative to the population's degree of wealth and urbanization. The presence of paper, plastic, glass, and metal becomes more prevalent in the waste stream of middle and high income countries.

2.3 Waste Trends

Waste quantities are inextricably linked to economic activity and resource consumption. Over the next 25 years, poverty in Asia is expected to continue declining (despite recent economic performance). If the pace of capital accumulation and productivity growth continues, then the wages of unskilled workers in all countries and regions are expected to increase substantially (World Bank, 1997c). Besides economic growth, Asian countries are also experiencing urban growth rates of approximately 4 percent per year; a trend that is expected to continue for several decades. By 2025, the Asian population is projected to be about 52 percent urban. Cities in developing countries are experiencing unprecedented population growth because they provide, on average, greater economic and social benefits than do rural areas (World Resources Institute, 1996). In fact, rural-to-urban migration is estimated to account for 40 to 60 percent of annual urban population growth in the developing world (McGee and Griffiths, 1994).

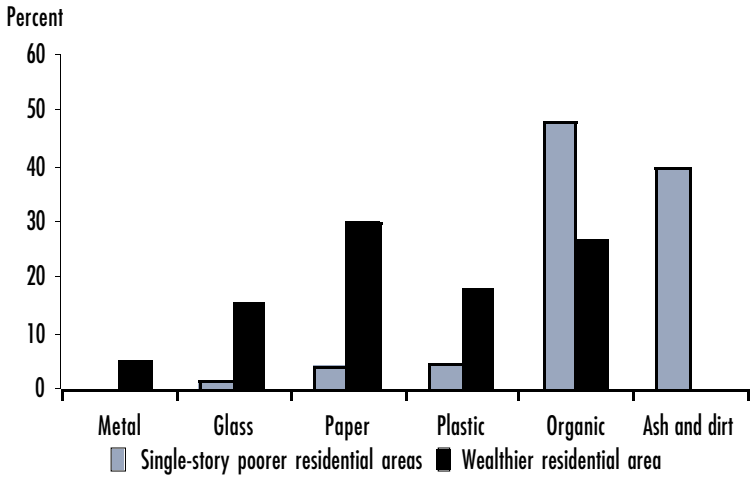
The economic and population growth experienced by many Asian countries follows similar material consumption trends as those found in the United States and other industrialized countries over the past century. As shown in Figure 22, the overall consumption rates in the United States dramatically increased as the economy prospered, despite periods where Americans experienced economic hardships such as the Great Depression in the early 1930's and the energy crisis of the mid-1970's.

Japan has experienced waste trends comparable to the United States over the past two decades. Waste quantities were rising until 1970, declined temporarily after the 1973 energy crisis, and then rose again slightly. As the economy prospered in the late 1980's, waste quantities increased sharply. However, since 1990, generation rates have stabilized due to an economic slow-down and the implementation of waste reduction policies (Japan Waste Management Association, 1996).

China is also experiencing rapid population and economic growth. Consequently, municipal solid waste is increasing in excess of 10

Figure 6: Variations in Waste Generation and Composition by Affluence: Beijing, China

Waste quantities and compositions vary not only between countries, but also between individual cities, and communities within a city. The figure below illustrates the differences between the waste compositions of two different residential areas in Beijing. The wealthier households produce significantly higher percentages of paper, plastic, metal, and glass wastes, most likely from packaging materials. Compostable matter, such as food, horticultural, and ash waste, are predominant in single-story residential waste streams. The high ash and dirt content is from coal since gas is not yet as widespread among the population (Beijing Environmental Sanitation Administration, 1996).



percent per year. Wuhan City, the capital of Hubei province, with a population of more than 6.8 million, has an extensive industrial base comprised of metallurgical industries, manufacturing, textiles, transport manufacturing, oil processing, pharmaceuticals, electrical equipment, construction materials, and food industries. According to the Environmental Protection Department for Wuhan City, MSW quantities have increased from 1.19 million tonnes in 1985 to 1.50 million tonnes in 1993 (Wei et al, 1997). Not only are the quantities of waste increasing commensurate with the growing economy and expanding population; the composition is also shifting towards plastic and paper packaging (see Figure 21), a reflection of improved living standards.

Figure 7: 2025 Urban Per Capita Municipal Solid Waste Generation

Country	GNP Per Capita in 2025 (1995 US $)	2025 Urban Population (% of Total)[1]	2025 Urban MSW Generation (kg/capita/day)
Low Income	**1,050**	**48.8**	**0.6-1.0**
Nepal	360	34.3	0.6
Bangladesh	440	40.0	0.6
Myanmar	580	47.3	0.6
Vietnam	580	39.0	0.7
Mongolia	560	76.5	0.9
India	620	45.2	0.7
Lao PDR	850	44.5	0.8
China	1,500	54.5	0.9
Sri Lanka	1,300	42.6	1.0
Middle Income	**3,390**	**61.1**	**0.8-1.5**
Indonesia	2,400	60.7	1.0
Philippines	2,500	74.3	0.8
Thailand	6,650	39.1	1.5
Malaysia	9,400	72.7	1.4
High Income	**41,140**	**88.2**	**1.1-4.5**
Korea, Republic of	17,600	93.7	1.4
Hong Kong	31,000	97.3	4.5
Singapore	36,000	100.0	1.1
Japan	53,500	84.9	1.3

[1]United Nations, 1995

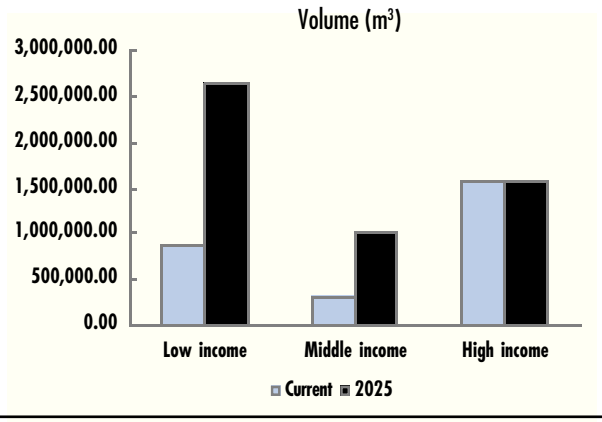
See Figure 3 to compare to current rates.

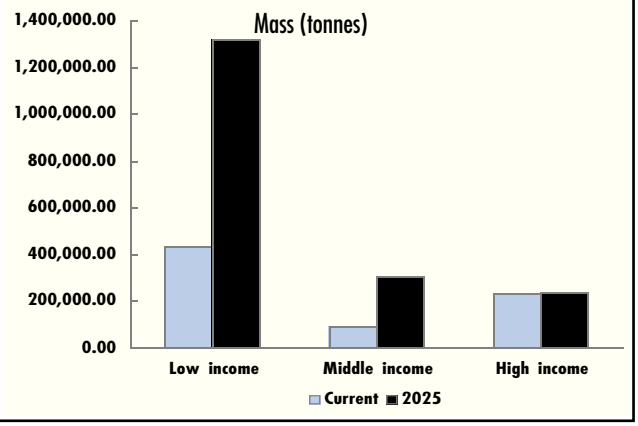
Historical waste generation patterns of both developed and developing countries, economic trends, and population predictions, and per capita municipal solid waste generation rates and compositions are estimated for Asian countries in 2025. (See Figure 7.) These estimates are conservative, but they demonstrate that most Asian countries, particularly the low and middle income countries, will have to deal with enormous quantities of urban waste with a changing composition in the years to come. Figure 2 compares and contrasts the urban waste composition and the total amount of waste generated by the current and future populations for these same countries.

The urban per capita waste generation rate for most of the low income countries will increase by approximately 0.2 kg per day because these countries have relatively high annual GNP growth rates and urban population growth rates. As China, India, and Mongolia become more prosperous and move away from coal as the traditional fuel, the ash composition will greatly decrease and the percentage of compostable organic matter will increase slightly. Packaging wastes, such as paper, plastic, and glass, will become more predominant in the waste stream as the economies increase and the population becomes more urbanized.

By contrast, the middle income countries should anticipate a per capita increase of about 0.3 kg per day since their economies are predicted to grow at the highest rates and will experience significant

Figure 8: Total Waste Quantities and Volumes Generated by Low, Middle and High Income Countries (per day)





population growth in the urban sector. Indonesia and the Philippines will be producing significant quantities of waste, which will require management with a still relatively small per capita GNP. Although Thailand and Malaysia will have the highest per capita waste production rates, they should have stronger economies and more resources to begin implementing integrated solid waste management plans. Overall, the waste composition is predicted to become even more variable as the percentage of compostable matter declines, and packaging wastes, especially paper and plastic, increase.

As a whole, urban populations from low and middle income countries will triple their current rate of municipal solid waste generation over the next 25 years. Nepal, Bangladesh, Myanmar, Vietnam, Lao PDR, and India can each expect their urban waste quantities to increase by about four to six times the current amount. By 2025, the low income countries will generate more than twice as much municipal waste than all of the middle and high income countries combined—approximately 480 million tonnes of waste per year. Such a dramatic increase will place enormous stress on limited financial resources and inadequate waste management systems.

The per capita municipal solid waste generation rate in high income countries is expected to remain stable or even decrease slightly due to the strengthening of waste minimization programs. The total amount of waste generated in 2025 will increase by a relatively small amount—about 1 million tonnes per day—compared to the current waste quantities. Construction activity in Hong Kong is expected to continue. No immediate proposals are underway regarding how to reduce construction and demolition wastes. Thus, wastes from this sector will remain high and keep contributing significantly to the municipal waste generation rate. Singapore and Japan both have the lowest waste generation rates of all the high income countries and even some of the middle income countries. However, their rates may reflect definition inconsistencies rather than waste minimization practices. Although these two countries have implemented integrated solid waste management plans, it is unlikely that they will significantly reduce their waste quantities below current levels. The overall MSW composition for high income countries is predicted to be relatively stable; only a slight decrease is expected in metal and glass wastes and increases should occur in plastic, paper and compostable wastes.

A different trend emerges when comparing waste amounts in terms of volume. Figure 8 shows average waste densities of 500 kg/m3, 300 kg/m3, and 150 kg/m3 were used to calculate the volume of waste generated for low, medium, and high income countries, respectively. Whereas the low income countries

currently produce the highest quantity of waste on a mass basis, the high income countries generate the most waste on a volumetric basis. This increase in volume is a result of paper, plastics, bulky wastes, and other multi-material packaging prevalent in the waste streams of wealthier and more urbanized countries. Low and middle income countries have a larger percentage of high density organic matter and ash residues in their waste streams which weigh more, but do not take up as much space, as discarded packaging materials and household goods.

In 2025, the high income countries are expected to generate about the same quantity of wastes, in terms of both mass and volume. Low income countries will be the largest generator of wastes on a mass basis, and will also surpass the total volume of waste produced by the high income countries. The increasing percentage of plastic and paper materials in the waste stream will contribute to the growing waste volume. In the next 25 years, both low and middle income countries will experience about a three-fold increase in their overall waste quantities and volumes, while South Korea, Hong Kong, Singapore, and Japan will stay relatively constant.

There is little doubt that the low and middle income countries of Asia are following a development path similar to the United States. (See Figure 2.) Compounding this is the fact that much of Asia's urban growth is occurring in very large cities, which exacerbates waste disposal and collection problems.

Figure 9: Global Paper Consumption Rates (1995)

Country	Per capita Paper Consumption[1] (kg/year)	Per capita GNP[2] (1995 US $)
USA	313	26,980
Japan	225	39,640
Hong Kong	220	22,990
Germany	190	27,510
United Kingdom	170	18,700
Australia	152	18,720
South Korea	128	9,700
Malaysia	62	3,890
Chile	39	4,160
Poland	31	2,790
Russia	30	2,240
Thailand	30	2,740
Brazil	28	3,640
Bulgaria	20	1,330
China	17	620
Egypt	11	790
Indonesia	10	980
Nicaragua	4	380
India	3	340
Nigeria	3	260
Ghana	1	390
Lao PDR	1	350
Vietnam	1	240

[1]Djuweng, 1997
[2]World Bank, 1997b

3.0 Consumer Societies

Industrialized countries comprise only 16 percent of the world's population, but they currently consume approximately 75 percent of global paper production. As shown in Figure 9, India, Indonesia, and China are three of the world's four most populous countries and among the lowest consumers of paper per capita. However, as their GNP and urban populations grow, their paper consumption and related packaging wastes will also increase. If they follow industrialized countries, their paper requirements will be enormous.

According to a 1992 study by the Indonesian Environmental Forum (Djuweng, 1997), Indonesian per capita paper consumption rose by 11.2 percent between 1981 and 1989. To meet local and international market demands and to fulfill its intention of becoming the world's largest pulp and paper producer,

Indonesia is planning to produce 13.2 million tonnes of pulp and 32.7 million tonnes of paper annually by 2000.

As countries become richer and more urbanized, their waste composition changes. The substantial increase in use of paper and paper packaging is probably the most obvious change. The next most significant change is a much higher proportion of plastics, multimaterial items, and "consumer products" and their related packaging materials.

More newspapers and magazines (along with corresponding increases in advertising), fast-service restaurants, single-serving beverages, disposable diapers, more packaged foods, and more mass produced products are all byproducts of widespread increases in local "disposable incomes." A negative side of greater affluence is that it brings with it more waste, of higher volume (making waste more expensive to collect). Often, increased use of plastic waste and food packaging results in a related rise in the amount of litter.

The rate of change in MSW quantities and composition in Asia is unprecedented. As lifestyles rapidly change, the related conveniences and products—mobile phones, electronics , polyvinyl chloride plastic (PVC) plastic, disposable diapers— pose special waste disposal challenges. Even more problematic is the fact that in most low and middle income countries, development of waste management systems woefully lags behind the realities of a quickly changing waste stream.

In addition, newly mobilized consumers and their market-savvy suppliers rarely consider the potential waste management problems that go hand in hand with changing lifestyles. The Coca-Cola Company is one telling example of how a multinational company may endeavor to increase its market share— in this case in China, India, and Indonesia. (See Figure 10). In its 1996 Annual Report, Coca-Cola reported to shareholders that two of its four key objectives were to increase volume and expand its share of beverage sales worldwide by "...investing aggressively to ensure our products are pervasive, preferred.…"

In another part of the report, the President of the company was quoted as saying "When I think of Indonesia—a country on the Equator with 180 million people, a median age of 18, and a Moslem ban on alcohol— I feel I know what Heaven looks like" (Barnet and Cavanagh, 1994). If the per capita consumption of Coca-Cola goes up by just one serving a year in China, India, and Indonesia, 2.4 billion containers would be added to the waste stream.

McDonald's Corporation has a similar expansion goal:

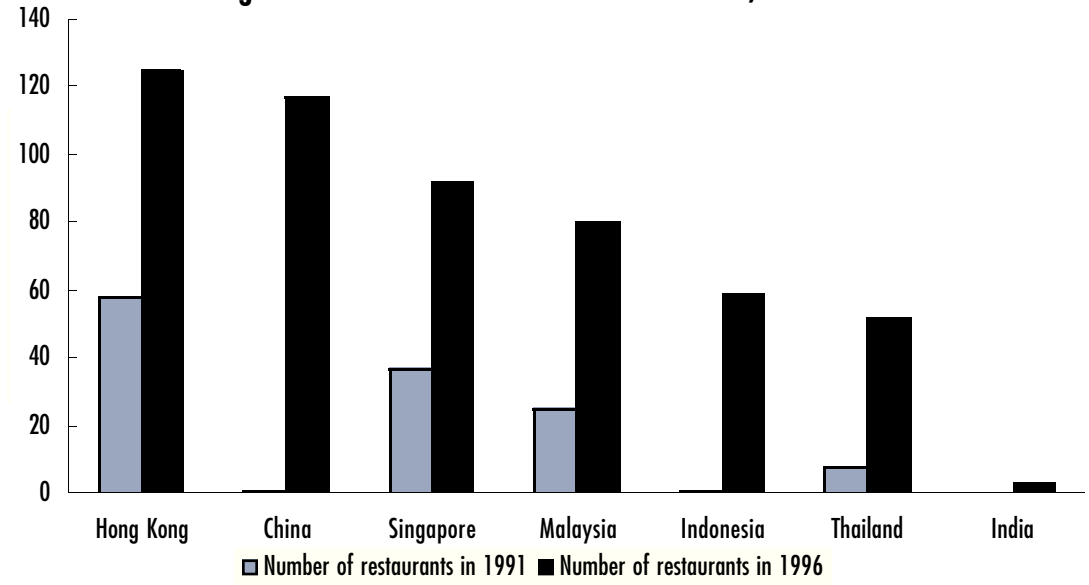
"The sun never sets on McDonald's, whether we're serving customers in the world's great metropolitan centers or near the picturesque rice fields carved into the landscape of the Indonesia island of Bali, McDonald's is at home everywhere." (McDonald's Corporation, 1997 Annual Report). In fact, McDonald's is actively expanding in Asia, and the company announced plans to triple its presence in China over the next three years. (See Figure 11.)

Figure 10: 1996 Per Capita Coca-Cola Consumption and Market Populations

Market	Population (millions)	Per capita consumption*
China	1,234	5
India	953	3
United States	266	363
Indonesia	201	9
Brazil	164	131
Japan	125	144
Philippines	69	117
Thailand	59	67
Korea, Republic of	45	72
Australia	18	308
Chile	14	291

*8-ounce servings of Company beverages per person per year (excludes products distributed by The Minute Maid Company)
(Coca-Cola Company, 1997)

Figure 11: Number of McDonald's Restaurants, 1991 and 1996



(McDonald's Corporation, 1997)

4.0 Business Involvement in Waste Management

4.1 Increased Partnerships

McDonald's and Coca Cola were mentioned previously as examples of companies that represent the overall shift toward a "consumer society." In pursuit of expansion, multinational corporations, with global marketing programs, undoubtedly change and increase the overall waste stream. On the positive side, many of the larger multinational corporations—such as McDonald's, Coca-Cola, and Unilever—often have progressive programs that address their specific, as well as the overall, waste stream.

By contrast, however, local national firms (e.g., bottled water vendors in Indonesia) are often even more prolific waste generators than their international counterparts. However, the larger multinational companies, with their global expertise, can also become powerful allies to local governments in the fight against waste. CEMPRE, which originally started in Brazil, is a good example of this type of collaborative partnership. (See Figure 12.)

More and more, governments are realizing that they can not handle waste management alone. To respond to the call, many progressive companies are working as equal partners with governments in developing comprehensive waste management programs.

4.2 Extended product responsibility

Extended product responsibility (EPR) is a voluntary measure, which places the onus upon the manufacturer to reduce the environmental impacts of their product at each stage of the product's life cycle—that is from the time the raw materials are extracted, produced and distributed, through the end use and final disposal phases. EPR does not consider only the manufacturers accountable for environmental impacts; this responsibility is extended to all those involved in the product chain, from manufacturers, suppliers, retailers, consumers, and disposers of products.

Figure 12: CEMPRE - Business Involvement in Municipal Solid Waste

The Brazilian Business Commitment for Recycling (CEMPRE) is a non-profit trade association that promotes recycling as a component of integrated waste management. Established in 1992, CEMPRE's members include a wide range of local and international companies, i.e., Brahma, Coca-Cola, Danone, Entrapa, Gessy-Lever, Mercedes-Benz, Nestle, Paraibuna, Procter & Gamble, Souza Cruz, Suzano, Tetra Pak, and Vega. The companies came together to ensure that their perspective on solid waste (particularly packaging issues) was considered by waste planners, and to help local governments in their waste management efforts.

CEMPRE educates the general public about waste and recycling through technical research, newsletters, data banks, and seminars. In addition, the organization provides, via the World Wide Web, tips on how to sell recyclable material; economic indicators on, and technical aspects of, waste collection and recycling; and a database on packaging and the environment (ECODATA). CEMPRE's programs are directed principally at mayors, directors of companies, academics, and non-governmental organizations. Active members have also promoted, and been granted, ISO 14001 certification, the international environmental certification system; and the Center for Packaging Technology works in partnership with the government and the private sector to improve packaging systems.

CEMPRE's involvement has extended beyond Brazil. Recently, the Latin American Federation of Business Associations for the Promotion of Integrated Solid Waste Management was created to exchange information among its members. The Association for the Defense of the Environment and Nature (ADAN) in Venezuela, CEMPRE/Brazil, CEMPRE/Uruguay, the Industry and Commerce Pro-Recycling Organization (ICPRO) in Puerto Rico, and Sustenta in Mexico, have formed a partnership.

Homepage: www.cempre.org.br

In the last few years, the governments of Germany, the Netherlands, and Sweden have each begun to develop comprehensive frameworks for EPR. In Germany, the Ecocycle Waste Act of 1994 sets general environmental goals for manufacturers. It provides guidelines for goods that are long-lived as well as those that can be re-used: regarding their reusability and recyclability; for using secondary materials in production; for indicating when products contain hazardous materials; and for returning products to suppliers at the end of their useful lives. The Dutch government implemented a new policy that requires distribution of life cycle assessment information at each stage for manufactured products. In 1994, Sweden designed a new law to promote more efficient use of resources in the production, recovery, and reuse of waste. The Swedish Ministry of the Environment and Natural Resources issued ordinances requiring increased return and recycling of consumer packaging, scrap paper, old automobiles, and used tires. In addition, Swedish battery manufacturers have voluntarily agreed to develop a recycling program for nickel-cadmium batteries (Davis et al., 1997).

4.3 Environmental Labeling

Environmental labeling of consumer products has helped raise environmental consciousness and momentum throughout Organisation for Economic Co-operation and Development (OECD) countries. Under environmental labeling programs, businesses voluntarily label their products to inform consumers and promote products determined to be more environmentally friendly than other functionally and competitively similar products. Environmental labeling can help achieve a number of goals, including improving the sales or image of a labeled product; raising consumers' environmental awareness; providing accurate, complete information regarding product ingredients; and making manufacturers more accountable for the environmental impacts of their products. Labeling programs are becoming more popular. These programs have been established in numerous OECD countries: Germany, Canada, Japan, Norway, Sweden, Finland, Austria, Portugal, and France (OECD, 1991).

In practice, however, the operation of labeling programs is more difficult than initially anticipated. Problems include the difficulty in assessing the entire life cycle of the product in a comprehensive way; becoming self-financed; or establishing product categories. Despite these difficulties, labeling of consumer

products has grown among countries and may potentially serve as an effective tool for environmental protection. To date, no studies quantify the effect of environmental labels on product sales or the subsequent environmental impact. However, a qualitative study of the German labeling program conducted by Environmental Data Services, Inc., in 1988 concluded that the environmental label fostered environmental awareness among consumers, expanded consumers' choice of environmentally friendlier products, stimulated the development of products with lesser environmental impact, and thus reduced waste, pollution, and domestic waste quantities (OECD, 1991).

4.4 Waste exchanges

Waste exchanges provide another practical way for businesses and industries to divert waste from disposal to a beneficial use. More than 50 waste exchanges exist in major centers across North America—such as New York, Chicago, and Toronto—and in most cases are provided as a free service to industries. Waste lists are published three to four times a year, some are updated monthly, and most exchanges have web sites on the Internet with links to other exchanges. Through waste exchanges, companies save thousands of dollars in avoided disposal costs or in obtaining raw materials at reduced prices. According to Dr. Bob Laughlin, former director of the oldest waste exchange in North America, the Canadian Waste Materials Exchange, materials listed on the exchange have a 20 percent chance of becoming diverted for useful purposes. It is also clear that Internet exposure is helping to increase the exchange rates (Buggeln, 1998).

Waste exchanges and industry response to projected waste quantities suggest that East Asian countries may benefit from working cooperatively in establishing secondary materials markets and from instituting consistent product and packaging design standards.

4.5 Pulp and Paper

Perhaps the next most important area for strengthened partnerships between business and government is in the pulp and paper industry. Businesses are undoubtedly aware of the huge potential Asian market. The pulp and paper industry should not be expected to reduce the growth of their products voluntarily; indeed, these industries have a natural desire to expand their markets. To meet the needs of business, Asian governments should aim for judicious use of legislation and market reforms to reduce resource consumption and waste generation rates, without impinging on economic growth. Paper is a good place to start.

Countries such as China, Indonesia, and the Philippines are well positioned to adopt more progressive tax measures because their government revenue bases are still relatively new. For example, in the United States, (a country that has a more established tax regime that is more difficult to modify), every tax dollar that is shifted from income and investment and placed toward resource use and pollution generation enables the economy to gain an additional 45 to 80 cents beyond the revenue replaced in the form of additional work and investment and in environmental damage averted (Sitarz, 1998).

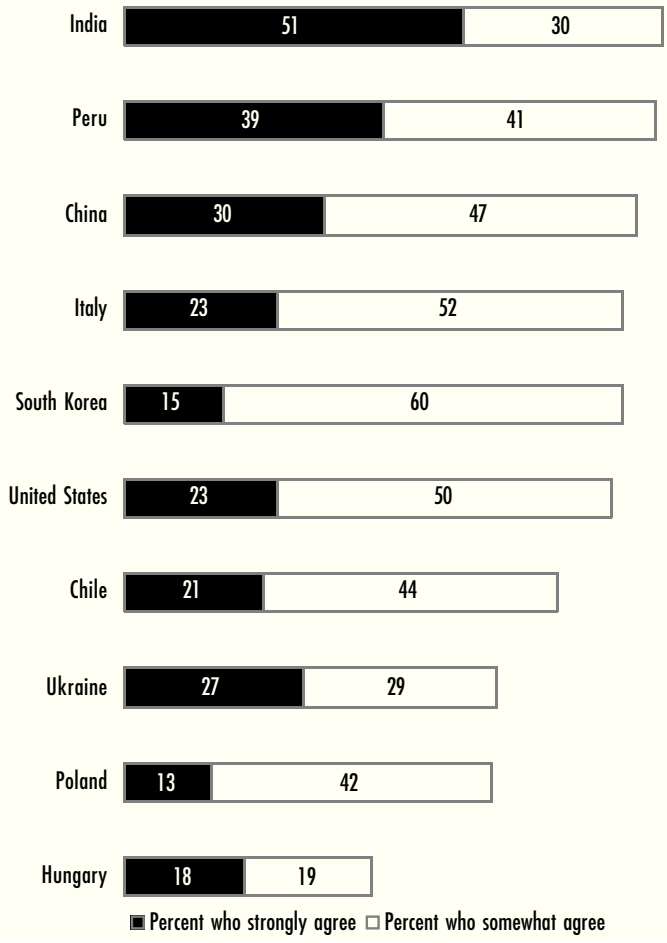
Figure 13: Results of Survey Asking Whether Respondents Felt That Their Health Was Affected by Environmental Problems

Country	Percentage of respondents who said a great deal or a fair amount
India	94
China	93
Hungary	92
Chile	88
South Korea	88
Peru	87
Poland	84
Italy	83
Ukraine	80

(Anderson and Smith, 1997)

Urban regions in Asia should begin to view their "urban ore" as an opportunity, as much as the disposal liability it now represents. For example, the Beijing or Jakarta regions in 2025 will produce more paper and metal than the world's largest manufacturing facilities. Robust, fair, and long-term partnerships should be sought with receptive resource manufacturers to incorporate these materials.

Figure 14: Results of Survey Question Asking Whether Respondents Would Contribute Part of Their Income if They Were Certain the Money Would be Used to Prevent Environmental Pollution



(Anderson and Smith, 1997)

5.0 Environmental and Health Impacts of Improper Solid Waste Management

Improper solid waste management causes all types of pollution: air, soil, and water. Indiscriminate dumping of wastes contaminates surface and ground water supplies. In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and floods during rainy seasons. Uncontrolled burning of wastes and improper incineration contributes significantly to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in landfills, and untreated leachate pollutes surrounding soil and water bodies. These negative environmental impacts are only a result of solid waste disposal; they do not include the substantial environmental degradation resulting from the extraction and processing of materials at the beginning of the product life cycle. In fact, as much as 95 percent of an item's environmental impact occurs before it is discarded as MSW.

Health and safety issues also arise from improper solid waste management. Human fecal matter is commonly found in municipal waste. Insect and rodent vectors are attracted to the waste and can spread diseases such as cholera and dengue fever. Using water polluted by solid waste for bathing, food irrigation, and drinking water can also expose individuals to disease organisms and other contaminants. The U.S.

Public Health Service identified 22 human diseases that are linked to improper solid waste management (Hanks, 1967. Cited in Tchobanoglous et al., 1993). Waste workers and pickers in developing countries are seldom protected from direct contact and injury; and the co-disposal of hazardous and medical wastes with municipal wastes poses serious health threat. Exhaust fumes from waste collection vehicles, dust stemming from disposal practices, and open burning of waste also contribute to overall health problems.

People know that poor sanitation affects their health, and nowhere is this link more apparent than in low income countries. Perhaps surprisingly, low income countries are also the most willing to pay for environmental improvements. Environics International Ltd. surveyed 24 countries, asking whether respondents believed that their health was affected by environmental problems. (See Figure 14.) India, China, and South Korea ranked among the top five countries that indicated their health was affected a great deal or a fair amount, with a response of 94, 93, and 88 percent, respectively. (Other Asian countries were not included in the survey). Figure 14 shows that these same countries also showed the highest positive response to the question of whether they would agree to contribute part of their income if they were certain the money would be used to prevent environmental pollution.

6.0 Integrated Solid Waste Management

Integrated solid waste management (ISWM) is defined by Tchobanoglous et al. (1993) as the selection and application of appropriate techniques, technologies, and management programs to achieve specific waste management objectives and goals. Understanding the inter-relationships among various waste activities makes it possible to create an ISWM plan where individual components complement one another. The UNEP International Environmental Technology Centre (1996) describes the importance of viewing solid waste management from an integrated approach:

- Some problems can be solved more easily in combination with other aspects of the waste system than individually;
- Adjustments to one area of the waste system can disrupt existing practices in another area, unless the changes are made in a coordinated manner;
- Integration allows for capacity or resources to be completely used; economies of scale for equipment or management infrastructure can often only be achieved when all of the waste in a region is managed as part of a single system;
- Public, private, and informal sectors can be included in the waste management plan;
- An ISWM plan helps identify and select low cost alternatives;
- Some waste activities cannot handle any charges, some will always be net expenses, while others may show a profit. Without an ISWM plan, some revenue-producing activities are "skimmed off" and treated as profitable, while activities related to maintenance of public health and safety do not receive adequate funding and are managed insufficiently.

Waste hierarchies are usually established to identify key elements of an ISWM plan. The general waste hierarchy accepted by industrialized countries is comprised of the following order:

- reduce
- reuse
- recycle
- recover waste transformation through physical, biological, or chemical processes (e.g., composting, incineration)
- landfilling

Figure 15: Comparison Of Typical Solid Waste Management Practices

Activity	Low income	Middle income	High income
Source reduction	No organized programs, but reuse and low per capita waste generation rates are common.	Some discussion of source reduction, but rarely incorporated in to any organized program.	Organized education programs are beginning to emphasize source reduction and reuse of materials.
Collection	Sporadic and inefficient. Service is limited to high visibility areas, the wealthy, and businesses willing to pay.	Improved service and increased collection from residential areas. Larger vehicle fleet and more mechanization.	Collection rate greater than 90 percent. Compactor trucks and highly mechanized vehicles are common.
Recycling	Most recycling is through the informal sector and waste picking. Mainly localized markets and imports of materials for recycling.	Informal sector still involved, some high technology sorting and processing facilities. Materials are often imported for recycling.	Recyclable material collection services and high technology sorting and processing facilities. Increasing attention towards long-term markets.
Composting	Rarely undertaken formally even though the waste stream has a high percentage of organic material.	Large composting plants are generally unsuccessful, some small-scale composting projects are more sustainable.	Becoming more popular at both backyard and large-scale facilities. Waste stream has a smaller portion of compostables than low and middle income countries.
Incineration	Not common or successful because of high capital and operation costs, high moisture content in the waste, and high percentage of inerts.	Some incinerators are used, but experiencing financial and operational difficulties; not as common as high income countries.	Prevalent in areas with high land costs. Most incinerators have some form of environmental controls and some type of energy recovery system.
Landfilling	Low-technology sites, usually open dumping of wastes.	Some controlled and sanitary landfills with some environmental controls. Open dumping is still common.	Sanitary landfills with a combination of liners, leak detection, leachate collection systems, and gas collection and treatment systems.
Costs	Collection costs represent 80 to 90 percent of the municipal solid waste management budget. Waste fees are regulated by some local governments, but the fee collection system is very inefficient.	Collection costs represent 50 to 80 percent of the municipal solid waste management budget. Waste fees are regulated by some local and national governments, more innovation in fee collection.	Collection costs can represent less than 10 percent of the budget. Large budget allocations to intermediate waste treatment facilities. Upfront community participation reduces costs and increases options available to waste planners (e.g., recycling and composting).

Despite progress in a few countries, fundamental environmental, financial, institutional and social problems still exist within all components of the waste systems in low and middle income countries of Asia. Recognizing that each country, region, and municipality has its own unique site-specific situations, general observations are delineated in Figure 15.

Common to all countries is an increasing awareness about the linkages between waste generation and resource consumption vis-a-vis sustainable development; greater involvement of the business community in recycling; and the increasing awareness of the value of source separation and marketability of good quality compost. Incineration is mainly used for volume reduction and its high costs will continue to inhibit its use. Siting for landfills is difficult, which often causes sites to be established in inferior locations. In addition, increasing attention is focused on reducing greenhouse gas emissions from waste.

6.1 Solid Waste Management Costs

MacFarlane (1998) highlights a relationship between per capita solid waste management costs and per capita GNP. As shown in Figure 16, cities in both developing and industrialized countries generally do not spend more than 0.5 percent of their per capita GNP on urban waste services. The 0.5 percent GNP value can be used by low and middle income countries as a general guideline to prepare waste management budgets and for planning. These costs, however, are only about one-third of the overall total. Additional costs are paid by businesses and residents, exclusive of municipal taxes and fees, Hoornweg (1992).

In Japan, municipal governments are responsible for solid waste management services and spent about 2,280 billion

Figure 16: Municipal Urban Waste Services Expenditures

City, Country	Year	Per Capita Expenditure on SWM (US $)	Per capita GNP (US $)	% GNP Spent on SWM
New York, USA	1991	106	22,240	0.48
Toronto, Canada	1991	67	20,440	0.33
Strasbourg, France	1995	63	24,990	0.25
London, England	1991	46	16,550	0.28
Kuala Lumpur, Malaysia	1994	15.25	4,000	0.38
Budapest, Hungary	1995	13.80	4,130	0.33
São Paulo, Brazil	1989	13.32	2,540	0.52
Buenos Aires, Argentina	1989	10.15	2,160	0.47
Tallinn, Estonia	1995	8.11	3,080	0.26
Bogota, Colombia	1994	7.75	1,620	0.48
Caracas, Venezuela	1989	6.67	2,450	0.27
Riga, Latvia	1995	6	2,420	0.25
Manila, Philippines	1995	estimate 4	1,070	0.37
Bucharest, Romania	1995	2.37	1,450	0.16
Hanoi, Vietnam	1994	predict 2	250	0.80
Madras, India	1995	1.77	350	0.51
Lahore, Pakistan	1985	1.77	390	0.45
Dhaka, Bangladesh	1995	1.46	270	0.54
Accra, Ghana	1994	0.66	390	0.17

(MacFarlane, 1998)

Figure 17: Japanese Expenditures for Solid Waste Management Services (1993)

Construction and repair expenses				Operation and maintenance expenses						
Intermediate treatment Facilities	Final disposal plants	Others	Research	Personnel	Collection and transportation	Intermediate treatment	Final disposal	Purchase of vehicles, etc.	Consignment	Others
828,712	108,300	26,274	18,672	619,482	85,545	190,419	39,474	18,646	281,327	66,494

(Japan Waste Management Association, 1996)

yen in 1993 on general waste services, accounting for approximately 5 percent of general municipal budgets. The breakdown of the country's waste expenditures is shown in Figure 17. Approximately 45 percent of the total budget is spent on intermediate treatment facilities, namely, incineration plants, compared to only 4 percent allocated towards collection and 6 percent for final disposal.

Compared to high income countries, municipalities in low and middle income countries allocate the majority of their solid waste management budget to collection and transportation services. Final disposal costs are minimal because disposal is usually accomplished through open dumping. In Malaysia, about 70 percent of the MSW budget is spent on the waste collection (Sinha, 1993). The City of Ahmedabad, India, spends about 86 percent of its solid waste budget on collection, 13 percent on transportation, and only 1 percent on final disposal (Jain and Pant, 1994). Typically, 90 percent of Indonesian solid waste management budgets is allocated for activities related to collection: street sweeping, transportation, and vehicle operation and maintenance. If a sanitary landfill is used for final disposal, collection costs decrease to about 80 percent (Cointreau-Levine et al., 1994).

Per capita and per ton waste management expenses of municipal governments have increased every year in Japan, as shown in Figure 18. According to a 1992 Japanese survey of about 3,250 municipalities, 35 percent of the respondents imposed charges for general waste management services and 636 municipal governments have adopted a fee structure, whereby the charges increase in relation to the amount of waste disposed. Revenues from waste fees cover only 4 percent of the total management expenses.

Figure 18: Japan's Solid Waste Management Expenses

	1986	1987	1988	1989	1990	1991	1992	1993
Expenses per capita (yen/capita/year)	8,554	8,898	9,419	10,257	11,112	12,795	14,818	18,272
Expenses per disposal amount (yen/ton/year)	24,253	24,165	24,583	25,949	28,107	31,924	37,591	46,280

(Japan Waste Management Association, 1996)

In low and middle income countries, some municipalities attempt to directly charge residents and commercial enterprises for waste services. Waste fees are often regulated by the local government and officially collected through a variety of forms, such as a general household sanitation fee, environment fee, or included in the water and electricity bill. Household and commercial waste service fees vary between cities and countries, as shown in Figure 19. Certain cities collect fees based on the amount of waste generated. Others only charge a flat rate per month or year. By contrast, some cities do not collect any fees at all; they completely subsidize solid waste services through general funds. Even when waste fees or taxes are imposed by the local government, waste managers often complain that fees are inadequate to cover the costs of waste services, the fee collection system is inefficient or unsupervised and subject to

illegal practices, or that collected money is not transferred directly to the waste management department, or that money is used for purposes other than solid waste management.

All residential areas in Jakarta are required to pay for primary waste collection, even if wastes are not adequately or regularly collected. The waste collection fees are configured based upon the community's affluence as well as the desired quality of service. The system places poorer residents at a disadvantage because the quality of their primary collection service suffers from the small revenues generated. Local governments also collect retribution fees to cover the costs of transportation and final disposal. Although regulations are in place to mandate the amounts to be paid by various waste-generating sources, the retribution fees actually collected are very low. In

Figure 19: Solid Waste Management Fees for Various Cities and Countries

City, Country	Household and Commercial Fees
Ulaanbaatar, Mongolia[1]	US $0.15 to 0.25/apartment/month US $0.50 to 0.85/peri-urban household/month Two main hotels each pay $8.10 and $18.77 per month per occupant, average 30 occupants
Hanoi, Vietnam[2]	US $0.55/person/year
Dhaka, Bangladesh[3]	Less than US $0.63/person/year, residents pay a Conservancy Tax for solid waste management
Vientiane, Lao[4]	US $12 to 216/household/year US $360 to 960/non-governmental commercial organization/year
Chennai (Madras), India[5]	Residents and businesses do not pay any direct waste fees, pay only property tax. Some households pay NGOs about Rs 15 to 20 per month for primary collection services.
Delhi, India[5]	Proposed system where homeowner has to pay a fixed amount of Rs 15 to 20 per month for collection services.
Beijing, China[6]	US $3 to 7.20/household/year
Shanghai, China[6]	Residents do not pay any direct waste fees.
Hong Kong[6]	Private and commercial establishments do not pay any direct waste fees.
Jakarta, Indonesia[6]	US $1.80 to 9.60/household/year
Denpasar, Indonesia[6]	US $6/household/year
Yangon, Myanmar[7]	Waste disposal tax is paid.
Thailand[8]	Public Health Act (1992) empowers local authorities to set up solid waste collection fees for households, commercial enterprises, markets, and industry according to fees announced in the Act.

[1]World Bank, 1998c
[2]URENCO, 1995
[3]World Bank, 1998a
[4]UNDP/World Bank Water and Sanitation Program, 1998
[5]Environmental Resource Management (ERM) India, 1998
[6]Johannessen, 1998
[7]Tin et al., 1995
[8]Public Health Act (1992) B.E. 2535, Thailand

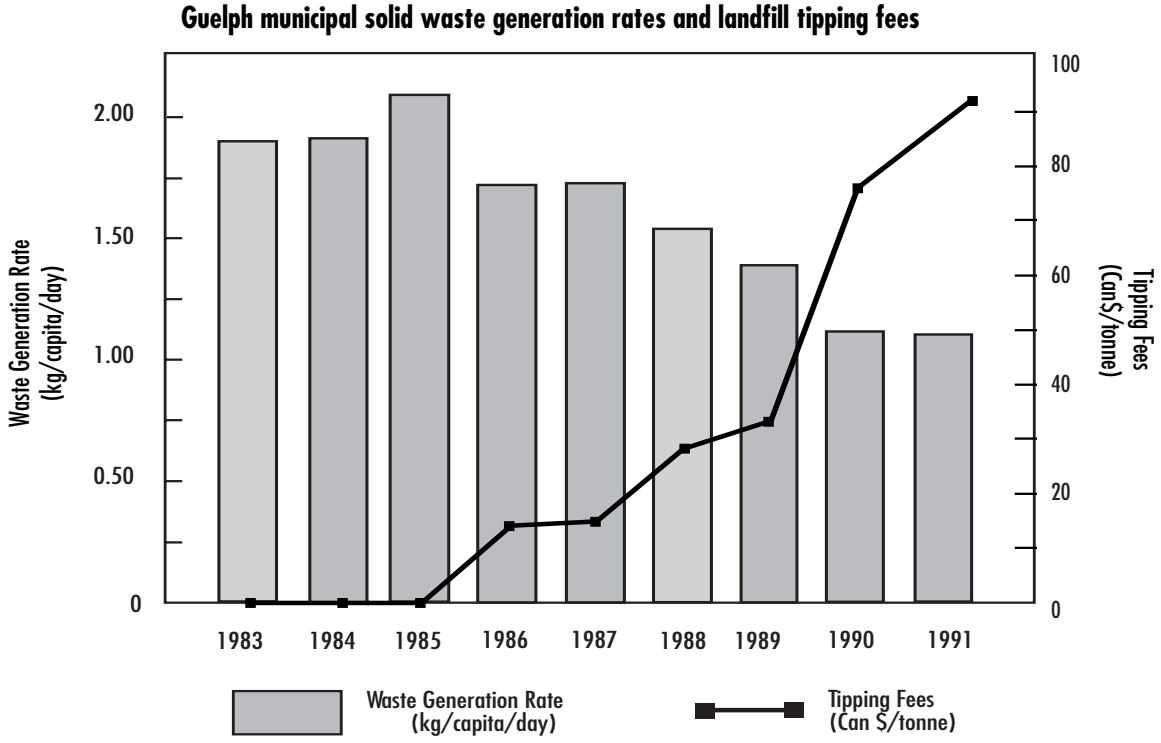
Jakarta, only 1 percent of the waste fees is transferred to the Cleansing Agency. To make up the difference in missing fees, the city uses its general fund to pay for this stage of waste management. The Cleansing Agency tries to collect door-to-door, but the system is seriously flawed because:

- collectors are few and part-time
- collectors lack incentive
- money passes through the hands of at least six agencies
- Cleansing Agency does not automatically keep the revenues (Porter, 1996)

Even if fees are imposed on the public for waste management services, they are usually priced on the basis of direct costs for limited activities, such as collection and landfill operations. Full cost accounting attempts to cover externalities and includes all waste management costs that are often only partially accounted for, or altogether ignored, such as:

Figure 20: Reducing Waste Quantities Through User Fees

The City of Guelph, Canada increased its landfill tipping fees gradually from no charge in 1985 to Can $92 per tonne in 1991. The figure below shows a corresponding decrease in the waste generation rates as the residents attempted to avoid disposal fees. Illegal tipping was not a cause of the reduction; rather, a greater awareness and corresponding change in business practices were the main reasons quantities decreased. The City of Date-shi, Japan reported a similar decrease of municipal waste quantities once disposal fees were introduced. The purpose of the new system was to gain financial resources to build new disposal facilities. Initially the authorities met with public opposition, but are now receiving cooperation from the local residents who have succeeded in reducing their waste quantities.
(Japan Waste Management Association, 1996)



(City of Guelph, 1991)

- disposal site selection studies and procedures
- public hearings, approvals, and permits
- design work
- capital costs
- operating costs
- development of infrastructure to support disposal facilities (e.g., access roads)
- social costs (e.g., declining real estate values, traffic congestion)
- closure and post-closure costs
- environmental costs (e.g., air and water pollution, noise) (Resource Integration Systems Limited et al., 1992)

7.0 Solid Waste Management Common Values

In order to help solid waste management practitioners, a few "common values," or strategies, can be proposed. There is a striking degree of similarity in municipal waste management needs and constraints across Asia.

1. Developing waste disposal facilities such as landfills and incinerators often generates tremendous concern—both warranted and reactionary. However, it is possible to reduce opposition to new facilities by involving the community and following a technically sound and transparent site selection process, and, wherever possible, using local conditions to ameliorate potential environmental impacts and costs, e.g., siting landfills in geotechnically superior locations. Waste disposal facilities, which often have a useful life in excess of 25 years, need to be well integrated within a sound master plan that reflects regional requirements, standard operating procedures, and financing mechanisms. Sound technical justification and a transparent planning process that respects the general public's valid concerns may not eliminate public opposition, but it is the best way to minimize it.

2. Local governments should minimize residential waste collection frequency to a maximum of twice per week, which is adequate from a public health perspective, but requires social acceptance. Citizens should be encouraged to place their waste in containers that enhance collection efficiency.

3. Local governments should focus primarily on residential waste collection, especially from poor and densely populated areas, and empower the private sector to pick up waste from non-residential sources. Commercial, institutional, and industrial waste collection can usually be self-financing. Local governments should license private haulers to generate revenues and to ensure proper collection and disposal.

4. Waste collection and disposal fees should be based on waste generation rates. Direct user charges and waste fee collection should begin with the business community.

5. An integrated approach toward solid waste management needs to be followed. Municipal waste managers should opt for the least technically complex and most cost-effective solution (e.g., limited mechanization and incineration). Waste diversion should be maximized.

6. All levels of government, including multi-national agencies and transnational corporations, must play a role in long-term program development, e.g., extended product responsibility, life-cycle analysis, waste exchanges, natural resources tax regimes.

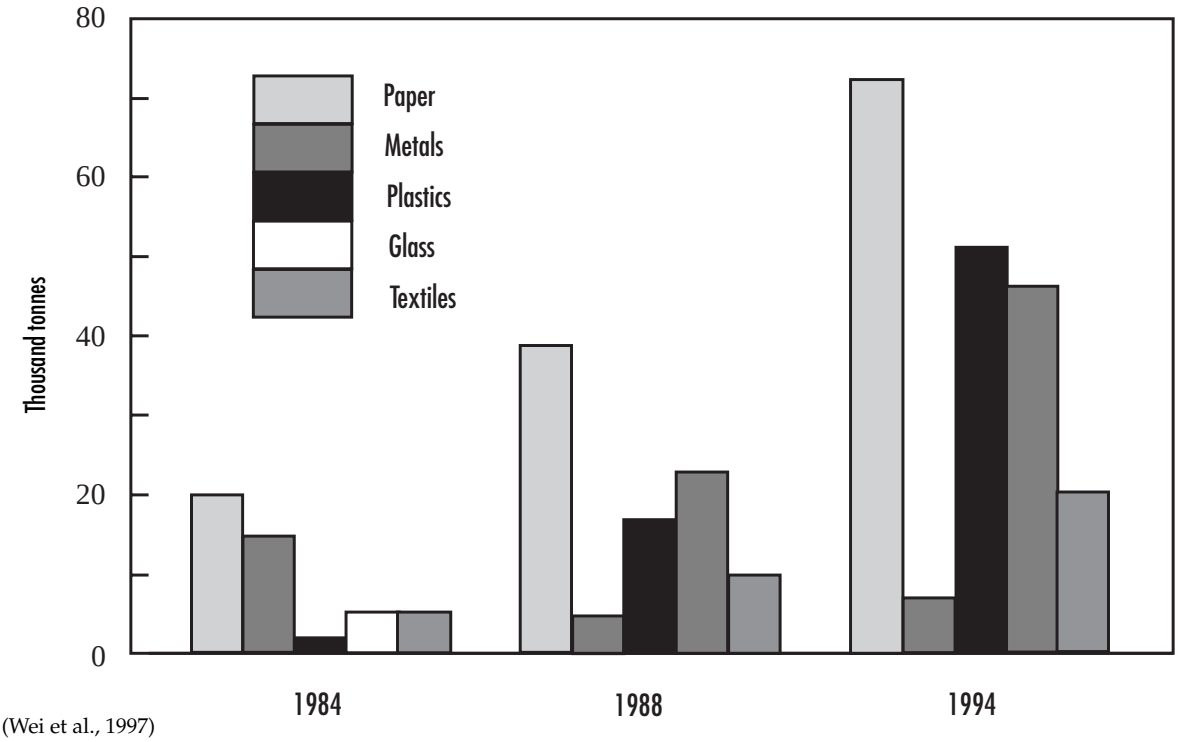
7. Local governments must honestly and respectfully gauge the public's willingness and ability to participate in the design and implementation of waste management programs. Through good partnerships, progressive programs can be developed in a complementary manner. These programs include community-based operations, micro-enterprise development, waste separation for increased recycling and composting, and reduced collection frequency.

8. All levels of government should promote the hierarchy of waste management (i.e., reduce, reuse, recycle, recover) and encourage waste separation to maximize flexibility to deal with future changes. Wherever appropriate, governments should view solid waste as a resource, rather than just a "local problem."

9. Although waste collection, treatment, and disposal costs often place a large burden on local government finances, improper disposal is far more expensive in the long run, with costs accruing over many years.

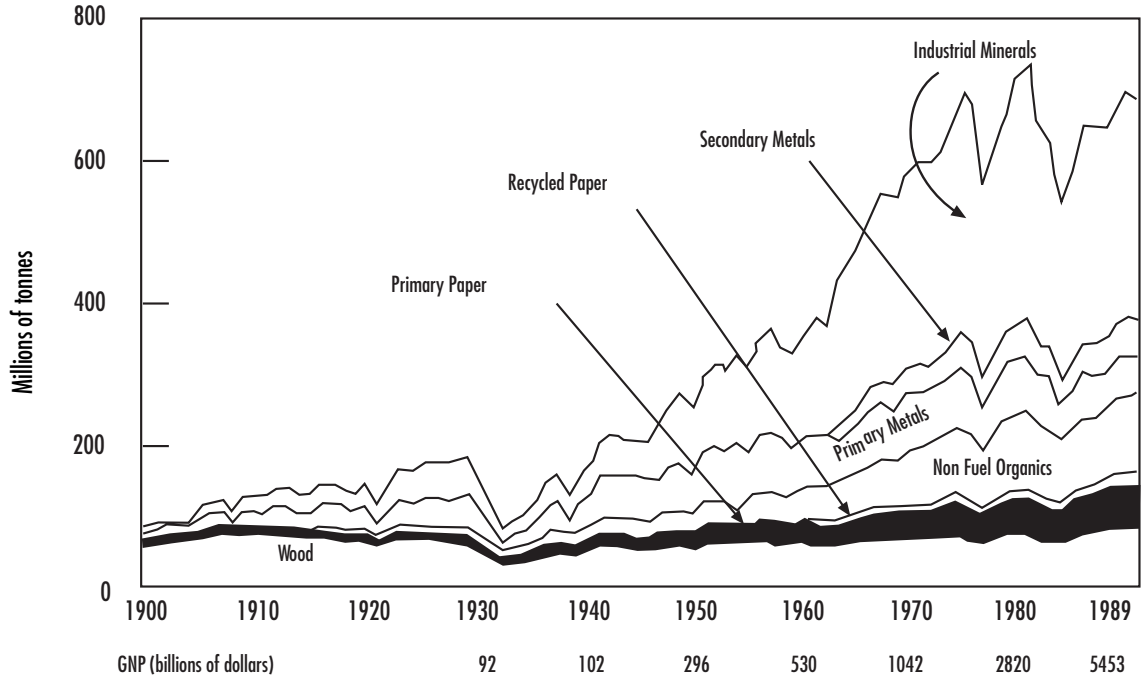
10. Local governments are usually in the best position to assume key responsibility for municipal solid waste collection and disposal. However, sustainable financing and sustainable service provision still needs to be defined by a broader set of stakeholders. Local governments need the assistance of all levels of government to provide waste management services efficiently. Regional approaches to waste disposal, e.g., shared landfills are especially important.

Figure 21: Wuhan City Waste Composition



(Wei et al., 1997)

Figure 22: United States Material Consumption Trends, 1900-89 (millions of tonnes)



(U.S. Bureau of Mines, 1993. Cited in Hammond, 1998)

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* indicates reference is for waste generation rate

◊ indicates reference is for waste composition

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Annex 1: Solid Waste Data

Waste data, including both generation rates and composition, should be considered with a degree of caution due to global inconsistencies in definitions of common terms and methodologies. The reliability of the data is questionable due to:

- undefined words or phrases
- units omitted
- inconsistent units used
- dates not indicated
- study methodologies not discussed
- estimates made without any basis
- incomplete data
- inconsistent values
- sources of information not referenced

In most low and middle income countries, the reliability of solid waste data is further reduced by large seasonal variations (e.g., seasonal rains and uncontainerized waste), incomplete waste collection and disposal (e.g., significant level of waste is disposed directly by the generator by burning or throwing in waterways and low lying areas), and a lack of weigh scales at landfill sites to record waste quantities.

It is rarely mentioned at what stage the waste generation rates and composition were determined, and whether they were estimated or physically measured. The most accurate method measures the waste at the source before any recycling, composting, burning, or open dumping takes place. However, the generation rate and composition are commonly calculated using the waste quantities arriving at the final disposal site. This way of measuring does not accurately represent the waste stream because waste can be diverted prior to final disposal, especially in low and middle income countries where the informal sector removes a large amount of recyclable waste during collection, transfer, and transportation. As well, in most low and middle income countries, waste collection efficiency is low and formal services do not extend to all communities, thereby reducing the quantities of waste delivered to disposal sites. Measuring waste quantities arriving for final disposal is most practical for municipal purposes, and large variations can be observed if the economic situation changes, yet growing waste quantities associated with increasing GNP are not necessarily a true reflection of increased waste; they may be attributable to changes in the relative scavenging value of the materials.

Waste composition indicates the components of the waste stream given as a percentage of the total mass or volume. The component categories used within this report are:

- compostables (includes food, yard, and wood wastes)
- paper
- plastic
- glass
- metal
- others (includes ceramics, textiles, leather, rubber, bones, inerts, ashes, coconut husks, bulky wastes, household goods)

"Others" wastes should be differentiated into two categories: "other-residue" and "other-consumer products." "Other-residue" is made up of ash, inerts, dirt, and sweepings and is a significant component of the waste

stream in low and middle income countries. "Other- consumer products" consists of bulky wastes, household appliances, electronics, and multi-material packaging (e.g., tetra-paks and blister packaging). This waste stream is much more significant in high income countries and differs from "other-residue" in that the volumes are much higher per kilogram of waste and are generally combustable.

It is important to cite whether the percentages are given on a dry or wet basis because the component percentages will differ markedly depending on the moisture content. Rarely is it indicated within a waste study whether the percentage is on a wet or dry basis, and/or based on volume or mass. It is assumed that the composition was determined on a wet basis because most countries have financial restrictions and a lack of physical resources to remove moisture from the waste. Probably both mass and volume measurements were used depending upon the country. Low and middle income countries would be more inclined to use volume since it does not require measuring equipment and can be estimated. High income countries probably used mass as a basis since they have greater funding resources and support to complete a more accurate waste characterization.

Table 1: Solid Waste Moisture Contents and Densities

City, Country	Moisture content (%)	Density (kg/m³)
Low income countries		350-550
Yangon, Myanmar[1]	n/a	400
Chongqing, China[2]	42.5	550
Qujing, China[3]	30.0	554
Dalian, China[4]	49.7	400
Middle income countries		200-350
Bangkok, Thailand[5]	49.1	350
Chonburi Municipality, Thailand[5]	56.3	210
Rayong Municipality, Thailand[5]	46.7	240
Batangas, Philippines[6]	27.4	262
Metro Manila, Philippines[6]	45.0	n/a
Kuala Lumpur, Malaysia[7]	n/a	270
High income countries		150-300
Seoul, South Korea[7]	n/a	302
Yokohama, Japan[8]	45.0	n/a

[1]Tin et al., 1995
[2]World Bank, 1997a
[3]Yunnan Institute of Environmental Sciences, 1996
[4]Ecology and Environment, Inc., 1993
[5]Pollution Control Department, 1998
[6]Department of Environment and Natural Resources, 1995
[7]UNCRD, 1989
[8]Japan Waste Management Association, 1997

Another major inconsistency among the various waste studies is the use of U.S. imperial units versus metric units. Frequently the U.S. imperial ton and the metric tonne are interchanged for one another when reporting waste quantities. Data are also denoted by the letter "t" to denote the unit, causing the true value to be unknown. Within this report, all of the units are metric, unless clearly noted.

Waste densities and moisture contents are needed to convert data to a common frame of reference for comparison (e.g., from mass to volume and from wet to dry). **Table 1** shows solid waste moisture contents and densities as reported by specific cities. Usually the higher the percentage of organic matter, the higher the moisture content and the density of the waste stream. The waste density of low income countries such as China, India, and Mongolia is further influenced by significant quantities of discarded coal ash residue. Low income countries have a wet waste density typically between 350 to 550 kg/m^3, middle income countries range from 200 to 350 kg/m^3, and high income countries from 150 to 300 kg/m^3.

Annex 2: Waste Generation Rates

ANNEX 2

Waste Generation Rates for Selected Asian Cities

Country	Year	Urban Population	Generation Rate (kg/cap/day)	Total Waste (kg/day)
East and North East Asia				
China				
Chongqing (1)	1997	2,752,000	1.2	3,302,400
Dalian (2)	1993	1,436,000	0.74	1,062,640
		1,436,000	0.33	473,880
		1,436,000	0.42	603,120
Shanghai (2)**	1993	8,206,000	0.6	4,923,600
Guilin (3)**	1995	557,000	0.85	473,450
Qujing (4)	1995	221,000	0.83	183,430
Beijing (5)	1991	11,157,000	0.88	9,818,160
Huangshi (11)	1993	570,000	0.87	495,900
Xiangfan (11)	1993	584,000	0.88	513,920
Yichang (11)	1993	391,000	0.88	344,080
Wuhan (6)	1993	6,800,000	0.6	4,080,000
		6,800,000	2.3	15,640,000
Hong Kong (7) Residential	1994	6,200,000	1.17	7,254,000
Misc.		6,200,000	0.26	1,612,000
Commercial		6,200,000	3.9	24,180,000
Japan				
Sapporo (20)**	1993	1,745,000	1.73	3,018,850
Sendai (20)**	1993	959,000	1.21	1,160,390
Chiba (20)**	1993	854,000	1.07	913,780
Tokyo (20)**	1993	8,022,000	1.5	12,033,000
Kawasaki (20)**	1993	1,202,000	1.2	1,442,400
Yokohama (20)**	1993	3,300,000	1.2	3,960,000
Nagoya (20)**	1993	2,153,000	1.16	2,497,480
Kyoto (20)**	1993	1,448,000	1.46	2,114,080
Osaka (20)**	1993	2,575,000	2.27	5,845,250
Kobe (20)**	1993	1,519,000	1.75	2,658,250
Hiroshima (20)**	1993	1,106,000	1.03	1,139,180
Kita-kyushu (20)**	1993	1,019,000	1.29	1,314,510
Fukuoka (20)**	1993	1,275,000	1.44	1,836,000
Korea, Republic of Seoul (8)	1989	10,500,000	1.59	16,695,000
Mongolia				
Ulaanbaatar (9)	1995	594,000	0.6	356,400
South East Asia				
Indonesia				
Jakarta (10)**	1993	9,160,000	0.66	6,045,600
Bandung (10)**	1993	2,368,000	0.71	1,681,280
Semarang (10)**	1993	1,367,000	0.69	943,230
Surabaya (10)**	1993	2,700,000	1.08	2,916,000
Yogyakarta (12)	1991	480,000	0.78	374,400
Padang (12)	1991	639,000	0.9	575,100
Ujung Pandang (12)	1991	844,000	0.86	725,840
Lao PDR				
Vientiane (13)	1998	180,000	0.58	104,400
			0.17	30,600
Khanthabouri (13)	1998	60,000	0.37	22,200
			0.25	15,000
Tharher (13)	1998	30,000	0.38	11,400
			0.08	2,400

ANNEX 2

Malaysia				
Kuala Lumpur (8)	1989	920,000	1.29	1,186,800
Penang (8)	1989	524,000	0.71	372,040
Bemban New Village (14)	1989	6,300	0.39	2,457
Temoh New Village (14)	1989	3,800	0.45	1,710
Kota Setar (15)	1990	188,000	0.79	148,520
Pulau Pinang (15)	1990	494,000	0.73	360,620
Ipoh (15)	1990	400,000	0.54	216,000
Kelang (15)	1990	242,000	0.79	191,180
Seremban (15)	1990	170,000	0.71	120,700
Johor Bahru (15)	1990	300,000	1	300,000
Kota Bharu (15)	1990	193,000	0.52	100,360
Kuantan (15)	1990	188,000	0.53	99,640
Melaka (15)	1990	196,000	0.46	90,160
Petaling Jaya (15)	1990	360,000	0.51	183,600
Myanmar				
Yangon (16)**	1993	2,513,000	0.45	1,130,850
Philippines				
Metro Manila (17)	1995	9,452,000	0.53	5,009,560
Baguio (17)	1995	227,000	0.36	81,720
Batangas (17)	1995	212,000	0.39	82,680
Tacloban (17)	1995	167,000	0.55	91,850
Iligan (17)	1995	273,000	0.38	103,740
Cagayan de Oro (17)	1995	428,000	0.54	231,120
Olongapo (17)	1995	211,000	0.39	82,290
Singapore (18)	1996	3,000,000	1.1	3,300,000
Thailand				
Bangkok (19)**	1998	5,876,000	1	5,876,000
Chiangmai (19)**	1998	167,000	1.87	312,290
Nakhonsawan (19)**	1998	152,000	1.11	168,720
Udonthani (19)**	1998	137,000	0.62	84,940
Nakhonratchasima (19)**	1998	278,000	1.41	391,980
Rachaburi (19)**	1998	n/a	2.78	n/a
Pattaya (19)**	1998	n/a	1.63	n/a
Phuket (19)**	1998	n/a	2.15	n/a
Songkhla (19)**	1998	243,000	1.11	269,730
Vietnam				
Halong (21)	1997	n/a	0.55	n/a
South Asia				
Bangladesh				
Rajshahi (22)	1991	2,213,000	0.5	1,106,500
Barisal (22)	1991	466,000	0.4	186,400
Khulna (22)	1991	1,609,000	0.5	804,500
Dhaka (22)	1991	5,966,000	0.5	2,983,000
Chittagong (22)	1991	2,619,000	0.5	1,309,500
Sylhet (22)	1991	255,000	0.4	102,000
India				
Ahmedabad (23)	1995	2,677,000	0.59	1,579,430
Bangalore (23)	1995	4,130,000	0.48	1,982,400
Bhopal (23)	1995	1,063,000	0.51	542,130
Bombay (23)	1995	12,288,000	0.44	5,406,720
Calcutta (23)	1995	9,643,000	0.38	3,664,340
Coimbatore (23)	1995	816,000	0.43	350,880
Delhi (23)	1995	8,412,000	0.48	4,037,760
Hyderabad (23)	1995	4,099,000	0.38	1,557,620
Indore (23)	1995	1,092,000	0.32	349,440
Jaipur (23)	1995	1,458,000	0.4	583,200

Kanpur (23)	1995	1,874,000	0.64	1,199,360
Kochi (23)	1995	670,000	0.52	348,400
Lucknow (23)	1995	1,619,000	0.62	1,003,780
Ludhiana (23)	1995	1,043,000	0.38	396,340
Madras (23)	1995	4,753,000	0.66	3,136,980
Madurai (23)	1995	941,000	0.39	366,990
Nagpur (23)	1995	1,625,000	0.27	438,750
Patna (23)	1995	917,000	0.36	330,120
Pune (23)	1995	2,244,000	0.31	695,640
Surat (23)	1995	1,499,000	0.6	899,400
Vadodara (23)	1995	1,031,000	0.39	402,090
Varanasi (23)	1995	1,031,000	0.4	412,400
Visakhapatnam (23)	1995	752,000	0.4	300,800
Nepal				
Kathmandu Valley (24)	1994	690,000	0.5	345,000
Sri Lanka				
Colombo (25)**	1994	615,000	0.98	602,700
Kandy (25)**	1994	104,000	0.58	60,320
Galle (25)**	1994	109,000	0.65	70,850

n/i means not indicated

n/a means not available

C&D means construction and demolition

**city population data are from United Nations, 1997.

(1) World Bank, 1997

(2) Ecology and Environment Inc., 1993

(3) World Bank, 1996

(4) Yunnan Insititute of Environmental Sciences, February 1996

(5) Beijing Environmental Sanitation Administration, 1996

(6) Wei et al., 1997

(7) Planning, Environment and Lands Bureau, 1994

(8) UNCRD 1989 "City Profiles," Supplemental document at the International Expert Group Seminar on Policy Responses Towards Improving SWM in Asian Metropolises

(9) Government of Mongolia, City Government of Ulaantabaar, and the World Bank, 1995. Generation estimates are from Ministry of Infrastructure Development (1996-97)

(10) Listyawan, 1997 (assumed density of 300 kg/m^3)

(11) Chinese Research Academy of Environmental Sciences, 1995

(12) UNDP/World Bank Water and Sanitation Program, 1993 (used 1990 population and assumed average density of 300 kg/m^3)

(13) Personal communication with UNDP/World Bank Water and Sanitation Program, RWSG-EAP, Lao PDR and Cambodia office, 1998. Based on actual survey conducted by the Institute of Urban Centres for its 1996-97 SWM Project

(14) Ogawa,1989

(15) Hani and Othman, 1992

(16) Cleaning Department, Yangon City Development Committee cited in Tin et al., 1995

(17) Capacity Building for Local Government Units on Environmental Management (Local-GEM), UNDP, EMB/DENR,1997; Urban Environment and Solid Waste Management Study, IBRO, EMB/DENR, 1995; and Study on Solid Waste Management for Metro Manila in the Republic of the Philippines, JICA, MMDA, 1997

(18) Signapore Ministry of the Environment, 1996

(19) Pollution Control Department, 1998

(20) Japan Waste Management Association, 1996 (population data from 1994)

(21) Kampsax International A/S, 1998

(22) World Bank, 1998 (waste quantities are estimated, the country is divided into 6 Administrative Divisions)

(23) Environmental Resources Management (ERM) India, 1995

(24) Consolidated Management Services Nepal Ltd., 1997

ANNEX 2

OECD Municipal Solid Waste Generation Rates

Country	Year	MSW Generation Rate[1]	Population[2]	Total Waste
		kg/capita/day		tonnes/day
USA	1992	2	263.1	526,200
Australia	1992	1.89	18.1	34,209
Canada	1992	1.8	29.6	53,280
Finland	1990	1.7	5.1	8,670
Iceland	1992	1.53	0.3*	459
Norway	1992	1.4	4.4	6,160
The Netherlands	1992	1.37	15.5	21,235
France	1992	1.29	58.1	74,949
Denmark	1992	1.26	5.2	6,552
Austria	1990	1.18	8.1	9,558
Japan	1992	1.12	125.2	140,224
Belgium	1992	1.1	10.1	11,110
Switzerland	1992	1.1	7	7,700
Turkey	1992	1.09	61.1	66,599
Hungary	1992	1.07	10.2	10,914
Sweden	1990	1.01	8.8	8,888
Germany	1990	0.99	81.9	81,081
Spain	1992	0.99	39.2	38,808
Italy	1992	0.96	57.2	54,912
Poland	1992	0.93	38.6	35,898
Portugal	1992	0.9	9.9	8,910
Mexico	1992	0.85	91.8	78,030
Greece	1992	0.85	10.5	8,925

[1]OECD, 1995

[2]World Bank, 1997b

*United Nations, 1995

ANNEX 2

1993 OECD Municipal Solid Waste Composition (percentage)						
Country	**Organic**	**Paper**	**Plastic**	**Glass**	**Metal**	**Other**
Canada	34	28	11	7	8	13
Mexico	52	14	4	6	3	20
USA	23	38	9	7	8	16
Japan	26	46	9	7	8	12
Australia	50	22	7	9	5	8
Denmark	37	30	7	6	3	17
Finland	32	26	0	6	3	35
France	25	30	10	12	6	17
Greece	49	20	9	5	5	13
Luxembourg	44	20	8	7	3	17
Netherlands	43	27	9	4	5	8
Norway	18	31	6	4	5	36
Portugal	35	23	12	5	3	22
Spain	44	21	11	7	4	13
Switzerland	27	28	15	3	3	24
Turkey	64	6	3	2	1	24
Average	38	26	8	6	5	18
(OECD, 1995)						
The following countries only consider household waste in the MSW composition: Canada, Denmark, Finland, France, Luxembourg, Netherlands, and Turkey						

ANNEX 2

Gross National Product (GNP) for Various Countries

Country	Assumed Annual Growth Rate (%)	1995 Per Capita GNP[1] (1995 US $)	Predicted 2025 Per Capita GNP (1995 US $)
China	3	620	1,505
Hong Kong	1	22,990	30,987
Japan	1	39,640	53,429
Korea, Dem.Peo.Rep.	2	240	435
Korea, Rep. of	2	9,700	17,570
Mongolia	2	310	562
Cambodia	2	270	489
Indonesia	3	980	2,379
Lao PDR	3	350	850
Malaysia	3	3,890	9,442
Myanmar*	3	240	583
Philippines	3	1,050	2,549
Singapore	1	26,730	36,028
Thailand	3	2,740	6,651
Vietnam	3	240	583
Bangladesh	2	240	435
India	2	340	616
Nepal	2	200	362
Sri Lanka	2	700	1,268

[1]World Bank, 1997b

ANNEX 2

Country	Current					2025				
	GNP per capita 19951	1995 Population		Urban Waste Generation		Predicted GNP per capita	Predicted Population		Predicted Urban Waste Generation	
		Total[1] (millions)	Urban[2] (% of Total)	Generation Rate (kg/cap/day)	Total Waste (tonnes/day)		Total[2] (millions)	Urban[2] (% of Total)	MSW (kg/cap/day)	Total (tonnes/day)
Low Income Countries										
Nepal	200	21.5	13.7	0.5	1,473	360	40.7	34.3	0.6	8,376
Bangladesh	240	119.8	18.3	0.49	10,742	440	196.1	40	0.6	47,064
Myanmar	240[2]	46.5*	26.2	0.45	5,482	580	75.6	47.3	0.6	21,455
Vietnam	240	73.5	20.8	0.55	8,408	580	118.2	39	0.7	32,269
Mongolia	310	2.5	60.9	0.6	914	560	3.8	76.5	0.9	2,616
India	340	929.4	26.8	0.46	114,576	600	1,392.1	45.2	0.7	440,460
Lao PDR	350	4.9	21.7	0.69	734	850	9.7	44.5	0.8	3,453
China	620	1,200.2	30.3	0.79	287,292	1,500	1,526.1	54.5	0.9	748,552
Sri Lanka	700	18.1	22.4	0.89	3,608	1,300	25	42.6	1	10,650
Middle Income Countries										
Indonesia	980	193.3	35.4	0.76	52,005	2,400	275.6	60.7	1	167,289
Philippines	1,050	68.6	54.2	0.52	19,334	2,500	104.5	74.3	0.8	62,115
Thailand	2,740	58.2	20	1.1	12,804	6,700	73.6	39.1	1.5	43,166
Malaysia	3,890	20.1	53.7	0.81	8,743	9,440	31.6	72.7	1.4	32,162
High Income Countries										
Korea, Republic o	9,700	44.9	81.3	1.59	58,041	17,600	54.4	93.7	1.4	71,362
Hong Kong	22,990	6.2	95	5.07	29,862	31,000	5.9	97.3	4.5	25,833
Singapore	26,730	3	100	1.1	3,300	36,000	3.4	100	1.1	3,740
Japan	39,600	125.2	77.6	1.47	142,818	53,500	121.6	84.9	1.3	134,210

[1]World Bank, 1997b

[2]United Nations,1995

*assumed GNP

Country waste generation rates are based on weighted averages from different cities within the country.

ANNEX 2

Composition of Urban Solid Waste in Asian Countries

Low Income Countries

Components	Nepal	Bangladesh	Myanmar	Lao PDR	India	Sri Lanka	China	Current	Est.
1995 Urban Population (in millions)	2.9	21.9	12.2	1.1	249.1	4.1	363.7	655	1,525.70
Year	1994	1992	1993	1998	1995	1993-94	991-95		2025
Type of Waste	MSW	Dom	Dom, Com	Dom, IC&I	MSW	Dom, Com	Dom, Com, MSW		MSW
Compostables	80	84.37	80	54.3	41.8	76.4	35.8	41.0	60
Paper	7	5.68	4	3.3	5.7	10.6	3.7	4.6	15
Plastic	2.5	1.74	2	7.8	3.9	5.7	3.8	3.8	6
Glass	3	3.19	0	8.5	2.1	1.3	2	2.1	3
Metal	0.5	3.19	0	3.8	1.9	1.3	0.3	1.0	4
Others	7	1.83	14	22.5	44.6	4.7	54.3	47.5	12

Nepal based on Kathmandu Valley.

Bangladesh based on Dhaka.

Myanmar based on Yangon.

Lao PDR based on Vientiane and Khanthabouri.

China based on Qujing, Guilin, Dalian, Wuhan, Beijing, Huangshi, Xiangfan, and Yichang.

India based on 23 metro cities.

Sri Lanka based on Colombo, Kandy, and Galle.

Middle Income Countries

Components	Indonesia	Philippines	Thailand	Malaysia	Current	Est. 2025
1995 Urban Population	68.4	37.2	11.6	10.8	128	296.7
Year	1993	1995	1995-96	1990		2025
Type of Waste	MSW	n/i	n/i	n/i		MSW
Compostables	70.2	41.6	48.6	43.2	57.5	50
Paper	10.9	19.5	14.6	23.7	14.9	20
Plastic	8.7	13.8	13.9	11.2	10.9	9
Glass	1.7	2.5	5.1	3.2	2.4	3
Metal	1.8	4.8	3.6	4.2	3.1	5
Others	6.2	17.9	14.2	14.5	11.1	13

Indonesia based on Jakarta, Bandung, and Surabaya.

Philippines based on Metro Manila, Batangas, Olongapo, and Baguio.

Thailand based on Bangkok, and the Municipalities of Chonburi, Rayong, Songkhla, and Chiangmai.

Malaysia based on 11 municipalities.

High Income Countries

Components	Singapore	Japan	Hong Kong	Current	Est. 2025
1995 Urban Population	3	97.2	5.9	106.1	112.3
Year	1990	1993	1995		2025
Type of Waste	MSW	n/i	Dom		MSW
Compostables	44.4	26	37.2	27.8	33
Paper	28.3	46	21.6	36.0	34
Plastic	11.8	9	15.7	9.4	10
Glass	4.1	7	3.9	6.7	7
Metal	4.8	8	3.9	7.7	5
Others	6.6	12	17.6	12.2	11

Singapore based on the entire country.

Japan based on Metropolitan Tokyo.

Hong Kong based on the entire country.