LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BTU/lb	British Thermal Unit per pound
C	Centigrade
CBO	Community Based Organization
cum	Cubic meter
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
GNP	Gross National Product
ISWM	Integrated Solid Waste Management
IWB	Itinerant Waste Buyer
kg	kilogram
km	kilometer
kpd	kilo per day
m	meter
MSW	Municipal Solid Waste
NGO	Non Governmental Organization
NIMBY	Not In My Back Yard
SWEEP	Solid Waste Management and Environment Enhancement Project
SWM	Solid Waste Management
td	ton/day
UN	United Nation
UNDP	United Nations Development Program
US$	United States Dollar
USA	United States of America
WHO	World Health Organization

I. Municipal Solid Waste Management in Asia and Africa: A Comparative Analysis

A. Introduction

Today, one of the major concerns of many municipal authorities of Asia and Africa responsible for overseeing public health and sanitation is management of Municipal Solid Waste (MSW). Inadequate infrastructure, financing and lack of clear roles and responsibilities of these authorities have made the task even more difficult. On the other hand, due to uncollected waste in the urban areas and uncontrolled disposal of waste at the city boundaries and the suburbs, public health and sanitation is threatened in several growing cites of Asia and Africa. This chapter describes the significance of municipal solid waste management in urban life, the recent trend of changes and the objectives of the report.

B. Significance of Municipal Solid Waste Management

Rapid urban migration, in search of better opportunities of livelihood, has resulted in an overwhelming demographic growth in many cities of Asia and Africa. At present, nearly 35 % of the population in these two continents is urban (fig1.1). Asian countries are experiencing an urban growth of approximately 4 % per year. This rate is expected to continue for several more years and by 2025, 52% of the Asian population is estimated to be urban. Like Asia, Africa's population is mainly rural at present. However, Africa is also experiencing a high rate of urbanization at 4 – 5 % per annum and by 2025, urbanization is likely to be same as in Asia.

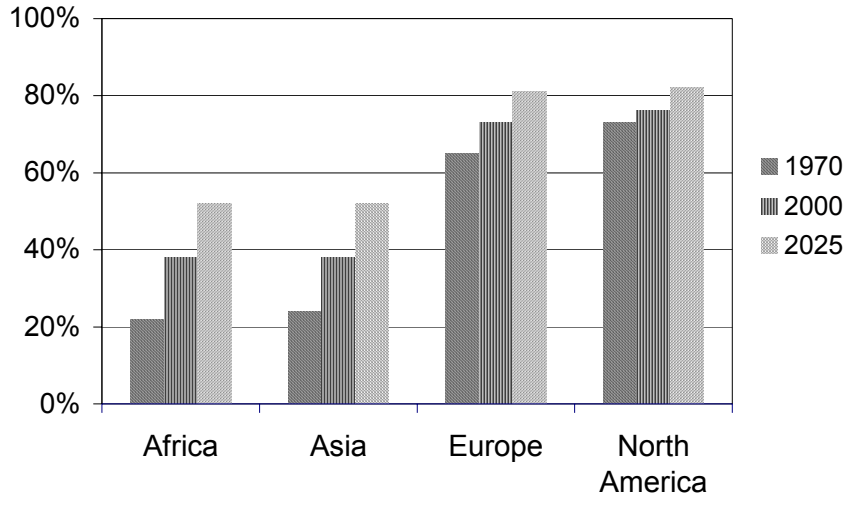

Fig 1.1 Projected Urban Growth in Different Continents (Source: UN, 1996)

This high rate of urbanization can lead to serious environmental degradation in and around several cities of the two continents. City utility systems, like MSW and sewerage collection and disposal, which were originally designed for a much smaller population, have already rendered inadequate to serve the rising population and expanding city boundaries. Generally, expansion and upgradation of these utilities remained much slower compared to the pace of increase in demand, resulting in rapid degradation of city life.

Several cases are reported about outbreaks of diseases primarily due to poor sanitary condition, waste handling and disposal facilities. For example, in 1994, 61,960 cases of cholera resulting in 4,389 deaths were reported in the states of Angola, the Democratic Republic of the Congo, Malawi, Mozambique and Tanzania, Africa (UNDP, 1997). Another 171, 000 cases of dysentery with at least 600 deaths were reported in Malawi, Mozambique and Zimbabwe. In October 1995, the outbreak of plague in Surat, India is considered to have originated from the uncollected solid waste in the city and clogged drains.

Municipal solid waste generation has been estimated (1998) to be about 60,000 tons/day (Martin, 1996) from the urban areas of Asia. This figure is predicted to increase by 30 times to 1.8 million tons/day by 2025. These estimates remain conservative due to lack of data and reliability of measurement techniques. The actual figures may very well exceed twice these estimates. By 2025, several developing countries in Asia, like Bangladesh, India, Laos PDR, Nepal, Myanmar and Vietnam are likely to experience a four to six times increase in MSW generation from the city and suburb areas, which may be disastrous to the city life if not taken care at an early stage.

Though reliable figures from the African countries are unavailable due to lack of data, it can be estimated that generation of MSW is also likely to increase at a high pace mainly due to rapid urbanization and population growth coupled with economic development in some countries of Africa. However, the pace of MSW generation in African cities is likely to remain lower than Asia due to slower economic growth and social unrest.

Traditionally, management of MSW has been a responsibility of the municipal authorities, which continue to oversee public sanitation in the cities. These bodies are either governmental or semi governmental in nature financed by the revenue collected in the form of municipal/corporation taxes or aided by the government directly. Unlike the developed countries of Europe and USA, where private and public participation in MSW management remained high, such structures barely exist in Asia or Africa, until recent past. Therefore, in

many cases, the quality of management is poor and several cases are noted when citizens complain about garbage lying uncollected (fig 1.2) for more than a week, spoiling the entire environment of the locality. In one of the cases in Calcutta, India, conditions were so severe that the citizen had to protest en masse.

Fig 1.2 Uncollected Wastes in Urban Areas.

Within the city areas, storage and collection of MSW has been the main problem. In many developing cities in Asia and Africa garbage are dumped in a small area at the end of the street or in a nearby open area giving rise to severe odor and littering by small animals, birds, street dogs and cats (fig1.3). Collection rate are poor and irregular, which allows the organic part of the garbage to putrefy forming potential sites for spread of diseases. House-to-house collection exists only in some metropolitan cities and in some designated area (mainly in the high-income area). In most of the medium to small sized cities, such services practically do not exist. The problems are more aggravated in and around the slum areas that exist in many small to large cities and in several metropolis of Asia and Africa.

Fig 1.3 Waste Littering by Street Animals and Birds

C. Recent Trend of Changes

Traditionally, management of MSW centered on collection of solid waste from the urban areas and hauling to the dumping site, where it was dumped without much environmental considerations. These dumping sites were often located near the city boundaries to keep the cost of hauling low. During the 60s, more emphasis has been put on waste storage and collection techniques and ways to improve it. Since about 90% of the MSW budget is consumed in collection and hauling to the dump yard, collection route optimization had been a top priority among different aspects of MSW management. Several studies have been made to optimize collection routes and methods of transportation to the dumping site. Invention of different equipment (e.g. compactor), development of special transport vehicles and establishment of transfer stations were the result of such efforts. During this era, little consideration was given to integrated waste management techniques in Asia and Africa though advanced countries of the west started adopting such techniques that ultimately proved to be more successful.

During the early 1970s the situation started to change when researchers and policy makers in the region became interested towards establishing a sustainable management plan driven by the success of the west and the pressure from increasing urban demands, due to rise in population. The debate shifted from technical issues of MSW management to amiable issues

of waste recycling and utilization. Technical and economical studies were performed for options of recovery and recycling of waste.

The concept of waste utilization and recycling seemed to particularly fit the Asian and African community, where economical advantages of waste utilization tends to drive many such projects. The fact that waste management is a fairly extended economic sector, comprising of a range of interlinked actors, activities, and commodities, has now been realized and accepted by many countries in the region. Current emphases are therefore focused (Chua and Garces, 1992) more on the ways and extent of recycling that reduces quantity of waste to be managed and preserves dwindling resources. Management goals have now included aspects of source segregation, waste reduction, recycling, community participation and employment generation in the sector.

Economic, social and environmental externalities are created due to unequal pricing and policies of waste generation and management at various levels of the community. This can lead to serious social and economic impacts and reduces the effectiveness of a MSW management plan. Therefore, in many communities in the region, efforts are underway towards a uniform policy and pricing structure to internalize these externalities taking into account the financial constraints at different income levels of the community (Hoornweg, 1998).

Therefore today, in some metropolis and large cities of Asia and Africa a new paradigm for MSW management has been established that incorporates more environment and economy friendly concepts of source separation, recovery of waste, legitimization of the informal systems, partial privatization and public participation. Such an integrated approach to MSW management is undoubtedly a better option and can well hold the key of sustainable solid waste management system (Hoornweg, 1998). Ironically, many small and medium cities specially in the poor and backward countries are still clinging to the old system of solid waste management and a large urban populous is devoid of an efficient service. For a healthy community in these cities, it is required that a sustainable solid waste management system with clear management goals are established, keeping in mind, the large demand looming on these cities in decades to come.

D. Objectives

This document is prepared to develop a comprehensive understanding of the underlying key aspects of MSW management in Asia and Africa. The report tries to analyze and compare these key aspects from the two continents, wherever reliable information is available. Several case studies highlight some of the strength and weaknesses of managing solid waste in the region. These practices cover many technical, management and institutional aspects that can form role models for several other underdeveloped and developing countries to adopt and put to work. Legislations, financial aspects challenges and recommendation forms a part of this report, which are expected to guide policy makers and administrators to develop their own strategies. It is expected that this report forms an effective information warehouse for development of sustainable MSW management plan for several metropolis, large, medium and small cities of the most populous continents of the world.

II. Technical Aspects of Municipal Solid Waste Management

A. Introduction

Solid waste management starts with solid waste characterization and quantification. It encompasses the full range of activities from generation to ultimate disposal of MSW that broadly comprises of generation, storage, collection / transportation and disposal. A lot of importance is given to resource recovery and recycling during the past few decades. Therefore resource recovery and recycling forms an integral part of today's MSW management. Each of these topics is discussed in this chapter along with factors influencing them. Outcome of several studies are given from various projects that tell the success and failure stories of different efforts that have been taken in these two continents. A brief description about the hazardous and toxic waste components (that is a subject of study in it's own right) is presented at the end of the chapter.

B. Waste Characterization

Characterization of solid waste constitutes the very first step of the whole planning and implementation cycle of a MSW management facility. Both technical and management practices vary depending on the character and quantity of waste being generated. Many failures of waste management, specially disposal techniques, could be attributed to failure of proper waste characterization and understanding its implication. Various factors affect waste characteristics and volume of waste generated, which are discussed later. However, depending on these factors the waste characteristics and volume can vary from city to city and even within the same city. At large, the principles of solid waste management for a particular city or an urban area need to be decided based on these parameters that are very much locale specific.

Solid waste characterization is the process of determination of the character of the solid waste. Quantification of waste is usually studied separately but is closely associated with waste characteristics. Waste characteristics depend mainly on the type of source from which it is generated. In general, there are six separate sources or generation points of solid waste in a municipal area, namely domestic, industrial, agricultural, institutional, commercial and

natural. The characteristics of solid waste from each of these sources vary widely. Table 2.1 lists the category of producers belonging to each of these sources and the main components of the solid waste that are generated from these sources. The proportion of these components is dependent on various other factors.

Table 2.1 Source and Main Components of Solid Waste from Urban Areas
(Source: Darmastuti, 2000)

Sources	Producers	Composition
Domestic	Household dwellings	Kitchen wastes, paper and cartons, plastics, rubber, leather, bone, glass, garbage, ashes and metals
Industrial	Construction sites, demolition debris, food processing industries, slaughter houses, manufacturing establishments and breweries, leather industries, carpets and garments factories, chemical plants and tourist facilities	Earth, brickbats, stones, sand and wood, packaging materials, food wastes, bones, feathers, hazardous wastes and old machine parts
Commercial	Stores, tea stalls, business premises, stores, restaurants, markets, fruit vendors, hotels and motor repair shops	Paper and cartons, glass, waste from food preparation, hair, ashes, spoiled, discarded goods and organic waste
Agricultural	Dairies, poultry farms, livestock and other agricultural activities like vegetable cultivation	Bio-degradable components, i.e., organic materials
Institutional	Hospitals, religious places, schools, banks, offices,	Paper and cartons, food wastes, glass, plastics, hazardous wastes and pathological wastes
Natural	Trees, plants and animals	Leaves, tree branches, seeds and carcasses of animals

In addition to the domestic waste, the hazardous and toxic waste component can be quite high in some Asian and African cities where regulatory and enforcement system to control such wastes is non-existent or not operating. Waste from hospitals and waste from some specific industries (like batteries, chemical, electronics) belong to this category and can be of particular problem if mixed with garbage from residential and commercial areas and disposed together. Storage, collection, handling and disposal of such wastes require special consideration to avoid serious impacts on the public health, property, environment and the ecosystem. Unfortunately, such considerations are not given or neglected by many of the municipal authorities in the developing countries in these two continents.

At this point, it is necessary to define what is meant by municipal solid waste. Some sources of data refer to only domestic or household waste as MSW, while others include several

other sources. Often, agricultural sources are excluded from the scope of MSW as the proportion of the waste generated from these sources tend to be quite low compared to others for most of the cities. The scope of the term MSW is important from practical standpoint as waste characteristics vary for each type of source. Quite often, waste management decisions depend on what is likely to constitute the MSW. For example, in many cases industrial solid waste or hospital waste is excluded from the scope of MSW and is never mixed or handled together with domestic and commercial waste. In these cases the responsibility of waste management from these sources lies with different authorities and waste collection, handling and disposal is carried out quite differently. In many cities in Asia and Africa, industries handle and dispose their waste by themselves as a large portion of the waste can be recovered or recycled.

In many other cities, where scope of MSW management are not well delineated, all the waste from a city including toxic and hazardous waste are handled together and very little effort is taken to handle and dispose (or treat) waste separately that is certainly not a good practice from many standpoints. In this report, the term municipal solid waste would mean all solid waste generated from various sources in a city, excepting wastes that can be considered as hazardous and toxic (hospital waste).

The choice of the definition is based on the fact that solid waste can also be broadly categorized into two major types, namely organic and inorganic. Organic solid waste is that part of the waste that is organically decomposable e.g. food waste, while inorganic solid waste is that part which is not easily decomposable e.g. plastics. Thus though the general characteristics of waste varies from source to source the management and technical aspects of handling and disposal of organic or inorganic waste are broadly same, irrespective of the source from which these come from.

The proportion of solid waste from different sources that constitute the MSW in a city depends mainly on the number of industries, commercial and institutional setups that the city is hosting. There is no general rule by which the proportion of solid waste from different sources can be accurately estimated. For example, in many industrialized cities and metropolis in Asia and Africa, waste generated from residential areas may constitute only 30% of the total waste stream whereas for other small or medium cities, which are predominantly residential, domestic solid waste can be as high as 65 – 70%. Table 2.2 shows the relative proportion of solid waste that constitutes the MSW for Nairobi, Kenya during the year 1972 – 1988. The figure shows how the relative proportion changed as the city was industrialized and population increased due to high urban drift.

Table 2.2 Proportion of Waste from Different Sources in Nairobi, Kenya
(Source: Nairobi City Council and African Urban Quarterly, 1992)

Year	1972		1975		1980		1988	
Population	617,000		669,222		868,028		1,300,000	
	td	kpd	td	kpd	td	kpd	td	kpd
Domestic Waste	300	0.65	560	0.8	1100	1.0	2440	1.3
Industrial Waste	70	-	120	-	200	-	550	-
Earth Waste	100	-	110	-	130	-	160	-
Total	470	-	790	-	1430	-	3110	-

- not available

C. Waste Composition

An indivisible part of waste characterization is determination of composition of waste that plays a key role in the waste management practices. In fact, the waste handling and disposal techniques depend more upon the constituents of a MSW than on any other single factor. Therefore, it is necessary to determine the composition of waste as accurately as possible before any technical and management steps are taken for a solid waste program. However, this is one of the most difficult aspects to determine as the composition of waste goes on changing from season to season and year-to-year, as urbanization and economic growth continues. The several factors inflicting changes to the composition is discussed in the next section.

In table 2.3 and table 2.4, the percentages of some of the major components (as given in table 2.1) of MSW are shown for different cities of Asia and Africa respectively. Wide variations can be noted between the composition of waste from one city to the other and no generalization can be drawn. Similarly, the composition of waste from different areas of the same city is found to vary (table 2.5) due to varying activities and nature of these areas. Comparing the two tables (2.3 and 2.4) it is seen, that for African cities the organic portion of the MSW is higher and inorganic portion lower, probably due to less industrialization of the African cities and lower per capita income compared to Asia as discussed in the next section.

Table 2.3 Waste Compositions in Asian Cities

(Source: Einsiedel, 1998)

Component	Brunei Darussalam	Delhi	Manila	Bangkok	Malaysia	Singapore
Food waste	37.0	52.7	10.0	55.0	56.0	45.0
Yard & field waste	-	33.6	31.0			
Paper	26.0	5.9	11.0	19.0	25.0	28.0
Rubber / Leather	1.0	3.6	2.0	-	-	3.0
Cloth	2.0	-	5.0	-	-	-
Wood	2.0	-	11.0	-	-	-
Plastic	13.0	1.5	9.5	10.0	8.0	11.0
Metal	11.0	0.6	4.0	4.0	6.0	-
Glass	6.0	0.3	2.0	6.0	3.0	4.1
Others	2.0	7.5	14.5	6.0	3.0	9.0
Heat value	4800 BTU/lb	-	7032 BTU/lb	-	-	-

- not available

Table 2.4 Waste Compositions in African Cities

(Source: Habitat, 1996)

Composition (% by weight)	Cities				
	Kumasi/ Ghana	Accra / Ghana	Ibadan / Nigeria	Kampala / Uganda	Kigali / Rwanda
Organic	84.0	85.1	55.8	75.0	94.0
Plastic	-	3.4	6.3	-	-
Glass	-	1.9	1.8	-	-
Metal	-	2.6	-	-	-
Paper	-	4.9	12.9	-	-
Inert	-	-	-	-	-

- not available

Table 2.5 Waste Compositions from Different Areas in the City of Accra, Ghana

(Source: Martin, 1996)

Waste Components	Cantonment areas to house to house collection	Market refuse new town market	Public dumping area Kaneshie	Accra composite
Vegetables and Putresciables	69.0	96.4	90.9	87.1
Paper	15.5	2.1	3.0	5.7
Metal	7.0	0.01	2.2	2.6
Textile	1.9	0.51	1.1	1.2
Glass	1.5	0.01	0.7	0.7
Plastic	3.7	0.04	0.5	1.3
Miscellaneous	1.4	0.93	1.6	1.4
Total	100%	100%	100%	100%

D. Factors Affecting Characteristics and Composition of Waste

Several factors affect characteristics and composition of waste. Some of the major factors are discussed in the context of these two continents.

Economy

Waste composition and the volume of waste generation are strongly affected by economic changes. Figure 2.1 shows the correlation between average per capita income and the quantity of waste generation from household. It is found that the quantity of waste generation is directly proportional to the economic growth. Studies show that for every Indian Rupees 1,000 (US $ 1 = Rupees 47) increase in monthly income, solid waste generation increases by a kilogram. Increase in GNP vis-à-vis per capita income encourages consumption and luxury. This tends to increase waste generated, as quantity of waste is directly proportional to consumption. Quantity of waste also increases due to increase in population (spurred by economic opportunities).

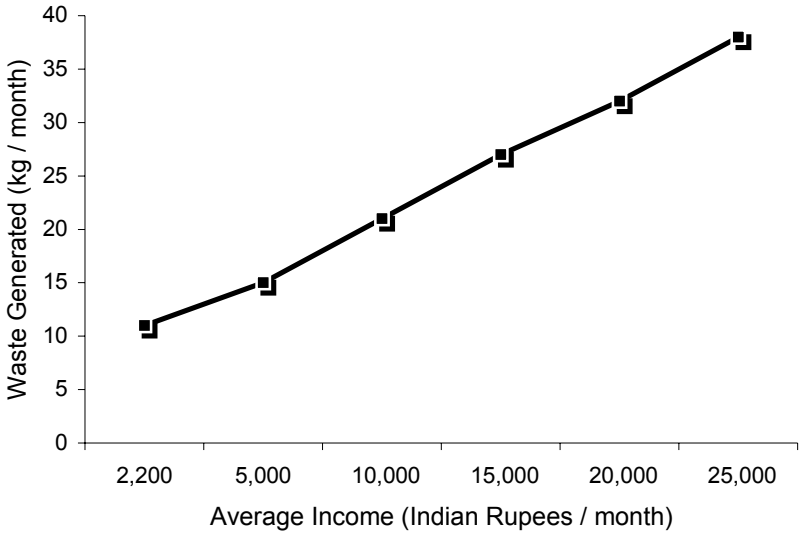

Figure 2.1 Correlation of Per Capita Income with Waste Generation
(Source: Darmastuti, 2000)

The characteristics of waste generated or the share of components tends to change with economic change. During the 1990s, many cities of these two continents saw a rapid industrialization and urbanization due to economic growth. This produced a shift towards use of more convenience-oriented (disposable) items like plastic bags, paper wraps, metal cans,

cardboard boxes etc. The traditional use of recyclable materials like cloth bags, glass bottles diminished and general awareness of the importance of recycling reduced. The high percentages of these convenience-oriented items (refer table 2.3) for a number of Asian cities are a reflection of low recycling due to higher affordability. In general, higher the income, higher is the level of inorganic or non-biodegradable items, which are more difficult to dispose in the Asian context (Chua and Garces, 1992). A comparison of organic and inorganic components in the MSW from high, middle and low-income countries (fig 2.2) supports this observation.

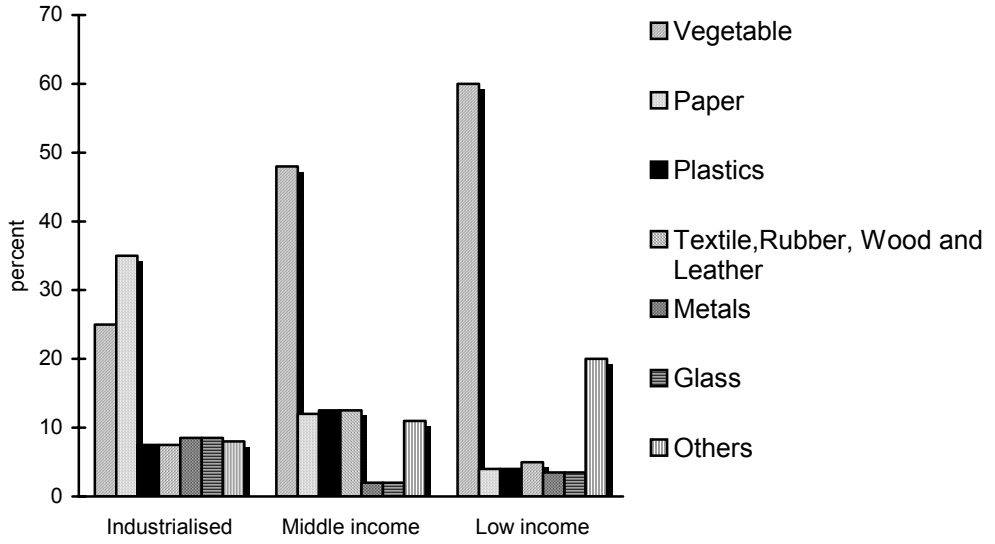

Figure 2.2 Comparison of Waste Composition from the High-Income and Low-Income Countries of Asia
(Source: Chua and Garces, 1992)

The comparison of waste characteristics for high-income and low-income residential area is shown in fig 2.3. The figure shows how economic difference can affect waste characteristics even for a single city.

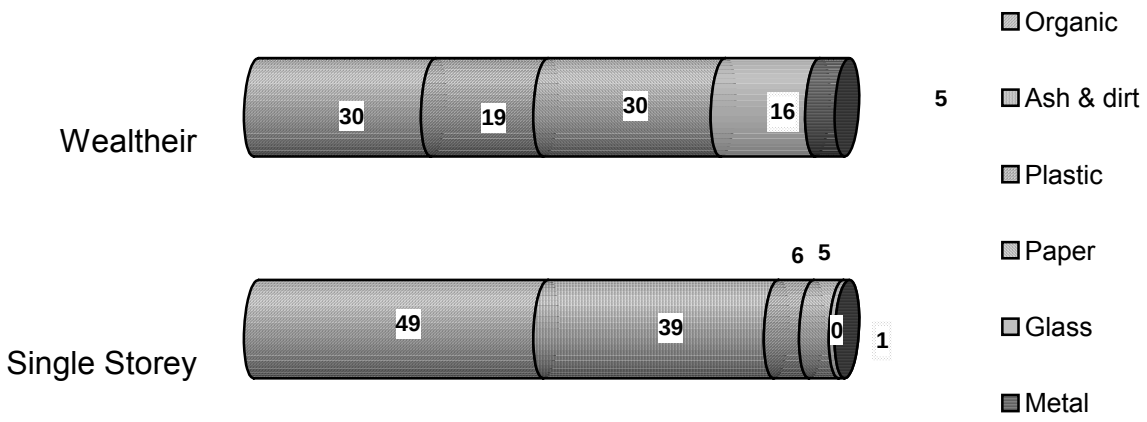

Figure 2.3 Comparison of Waste Composition from the High-Income and Low-Income Residential Area in Beijing, China
(Source: Martin, 1996)

Urbanization

Urbanization is a by-product of economic growth. More and more people are attracted towards the cities in search of better opportunities and better life. Industries, commercial and institutional buildings tend to cluster within the city mainly because of the infrastructural facilities that enhances productivity and efficiencies. Better job prospects leads to development of satellite residential area and spurs population density. Quantity of waste generation increases with increase in population and waste characteristics change due to increase in the income. With industrialization, waste generated from industries and associated commercial areas increases, and the proportion of organic portion reduces while inorganic portion increases. In Lagos, Nigeria solid waste generation increased by six fold to about 3.7 million tons a year in 1990 due to rapid urbanization. Additionally, industrial waste (practically untreated) increased by about half a million tons due to rapid growth of industries. Since about 90% of the industries in Nigeria, lack pollution control facilities the industrial waste are handled and disposed along with the domestic waste.

Culture

Traditionally, in Asia, recovery of usable items from the garbage and use of recyclable products like cloth bags, glass bottles, metal containers are promoted at the household level specially at the middle income and lower income levels. This is due to the basic education, culture and due to financial reasons. For example, in Karachi, Pakistan, out of 6,600 tons of household solid waste generated, about 800 tons are recovered everyday by housewives at the source. This reduces the total volume of waste by about 12%. This pattern is not much noticed in the affluent class, where higher amount of waste is generated due to less recovery and use of more disposable items.

In Asia (except for Japan and Singapore) and Africa, unlike most western countries, solid waste does not consist of refrigerators, television sets and other electronic equipments. This is because these items are not perceived as waste and most of these are recovered or reused. However, use of other recycled products and more environment friendly products are less common in these societies due to lack of information about the products, ecological awareness and economic incentives.

In most of the Asian and African societies, rag pickers or the scavengers are not accepted or their contribution to waste management is not recognized thereby discouraging a concerted effort to recover resources from the waste. Similarly, both Asians and Africans tend to dispose waste at any open site/space without considering the consequences and impacts of such actions. The result of such dumping is littering of waste by animals and birds, breeding of insects and nuisance in the area. Collection and handling of these wastes becomes a problem. Absence of community awareness makes MSW management much more difficult.

Climate

Most Asian countries have tropical climates with high level of precipitation and humidity. High amount of precipitation adds a large quantity of moisture to the waste and increases the weight. The organic portion of the solid waste tends to decompose quickly due to the hot and humid condition and poses problems in handling and disposal of waste. Presence of moisture makes the waste unsuitable for incineration.

Africa’s climatic zones consist of humid equatorial zone in the western, eastern and central part, dry zone in the northern and southern parts away from the equator and humid temperate in between the equator and the northern and southern parts. Rainfall is more in

the central part and reduces in northern and southern parts. The moisture content in the solid waste in the central Africa is higher compared to the arid zones. In many of the countries situated in the central, western and eastern parts like the Republic of Congo, Tanzania, Madagascar hot and humid climate poses problems with the organic portion of the solid waste.

E. Generation

It has been mentioned earlier that both the composition and quantity of waste generated determine the principles of MSW management of a city. Various factors influence the quantity of waste being generated and in general, there is no rule to determine the quantity of waste in advance other than from statistical information. The two primary factors influencing the rate are per capita income and degree of urbanization of the city. However, there are several other factors that also affect the rate and sometimes, these factors can equally influence the generation rate.

In Asian cities, the average rate of MSW generation ranges from 0.5 to 1.3 kg/capita/day, which is found to have a direct correlation with the per capita income of the city. In an industrialized city like Singapore, where the per capita income is high, the rate of generation can be as high as 1.3 kg/capita/day, whereas in low-income cities like in India or Bangladesh, about 0.5 kg of MSW is generated on a per capita average. For middle-income cities like Bangkok, Thailand, an average rate is about 0.9 kg/capita/day. The waste generation rate in rural areas is found to be much lower compared to the urban areas in many of the countries in Asia.

In Africa, the per capita waste generation rate is also in the same range of 0.45 – 1.3 kg/capita/day. Table 2.6 shows the solid waste generation rate for different cities of Africa. It can be noted that the variation of generation rate is as large as in the Asian cities and for the same reasons.

Table 2.6 Solid Waste Generation and Collection Rates in African Cities

(Source: Asomani-Boateng and Haight, 1999)

City	Solid waste per capita (kg/year)	Households with garbage collection (%)
Abidjan/ Côte D'Ivoire	365	70
Ibadan/Nigeria	401	40
Kinshasa/Congo	438	Not available
Bujumbura/ Burundi	511	41
Lomé/Togo	693	37

The volume of waste generated varies from day to day and season to season. The rate is often less during the weekends compared to weekdays. This is primarily because a large number of people come to work in the big or medium cities from the suburb and nearby residential areas that lie beyond the city limits. For this reason the rate of generation remains high during the weekday and decreases during the weekends. Similarly, the quantity of waste generation increases during the festive days. For example, after a very popular festival in India, the amount of paper waste generated rises tremendously due to a huge amount of fireworks and crackers being used during the festival. Therefore, before a technical or a management plan to handle city's MSW can be adopted, the nature of city and future trends of change need to be studied in detail to project the future quantity of solid waste likely to be generated. Fig 2.4 shows a prediction of quantity of solid waste expected to be generated during the next 25 years, for high-income, medium-income and low-income countries. The figure clearly depicts that much attention is required for middle and low-income countries, where a high rate of increase is expected during the next years.

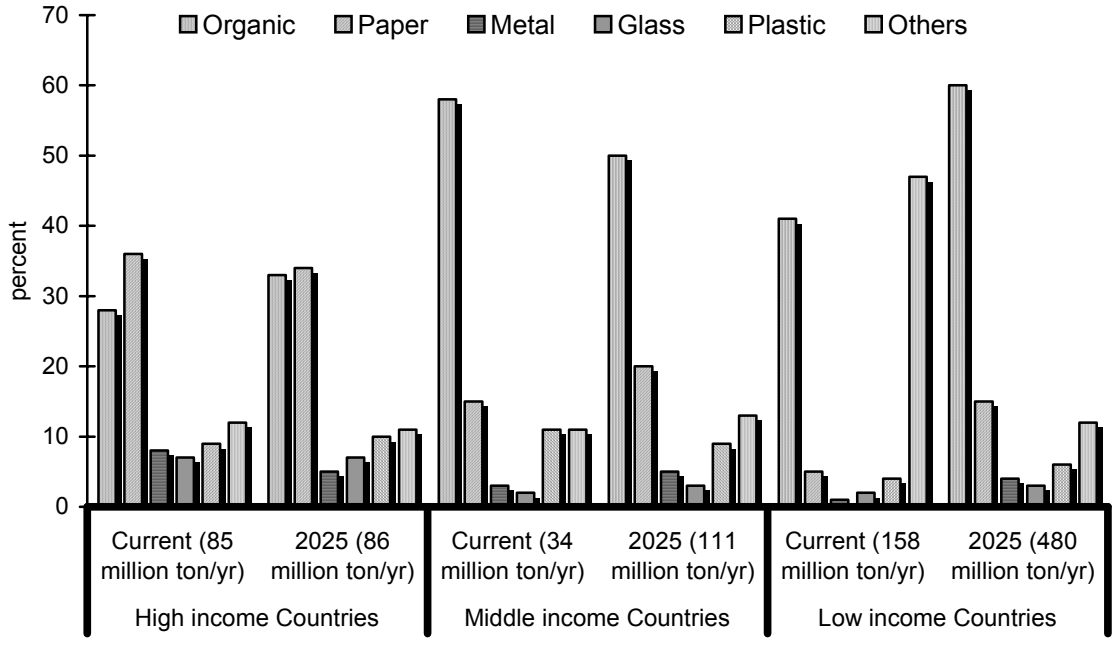

Figure 2.4 Current and Projected Waste Generation Rate for High-income, Middle-Income and Low-income Countries (Source: Martin, 1996)

F. Separation

Separation is the process of sorting the waste. Separation is carried out to recover reusable materials (resource recovery) from the waste and to aid solid waste management. Separation may include separation of wet waste, dry waste, hazardous waste (like batteries) and infectious wastes in order that these can be managed and disposed separately. Separation can be carried out at various places like at source or generation points, storage bins, collection points, transfer stations and disposal sites. In most of the cities in Asia and Africa, except some developed nations, separation of solid waste at the household level is carried out in order to recover useful materials and seldom these are done to facilitate handling and disposal of waste. Even in recent past, there was hardly any effort to encourage separation of waste at source aimed to help solid waste management, though it has been established that this practice can be is one of the best practices in solid waste management. Separation of metal, glass, plastic, paper and other inorganic matter from the organic portion of the solid waste helps improve collection, handling, recycling and disposal (fig 2.5). Separation also reduces volume of waste to be managed, chances of accidents for the waste handling crew, contamination with infectious matters, efforts to separate them at the collection points, transfer station or the disposal sites and processing activities (like washing). Disposal is also facilitated as organic matters are commonly composted whereas the inorganic portion is land filled or incinerated.

Figure 2.5 Photo Showing Waste Separation and Storage for Developed Countries

Several financial incentives and legal rules exist in the western countries to promote separation at source. Recently however, some efforts are directed to promote source

separation in developing countries in Asia and Africa. One of such efforts (box 2.1) has been undertaken in Jaipur, India. The study shows that by developing community awareness, promoting cooperation between the NGOs, municipal authorities and the community, waste separation at source can be successful.

Box 2.1 Case Study on Separation at Solid Waste at Source (household level)

In 1997, the Center for Development Communication (CDC), a Jaipur-based NGO involved in community development activities, looked at segregating waste inside the domestic premises through its 'Swachch Jaipur Abhiyan' project, which used the slogan "Look for garbage within first, and then beyond". CDC developed an innovative model for management of waste, which promoted household efforts to segregate organic and inorganic waste to aid the services of the municipal bodies. Initially funded by the Municipal Corporation, the program later became financially self-sustaining by charging a household collection fee of Indian Rupees 20 (US$ 1 = Indian Rupees 47) and selling by-products and using vermi-composting as a method of treatment of organic solid waste. The Municipal Corporation provided land, financial and monitoring assistance to the project. CDC advocated, organized the community and monitored the segregation of the household waste before collection. UNICEF also supported the program by promoting community and household vermi-composting. The waste producers collected the segregated waste at source. Inorganic waste was sent for recycling, while organic waste to vermi-composting by the Municipal Corporation. The program covers a population of 400,000 in Rajasthan and is rapidly expanding.

(Source: 'Effective Solid Waste Management With The Participation Of Waste Producers, Report from, Calcutta UNDP-World Bank Water and Sanitation programme and Seventh Meeting Of The Urban Think Tank, January 1999)

Depending on the technical and economic viability, resource recovery can also be practiced at one or all the stages of solid waste management. Resource recovery is the recovery of valuable materials from the waste stream that can be reused or recycled with or without further processing. Common materials recovered from the waste streams are paper, plastic, rubber, wood, metals, glass and leather. Reuse and recycling provide an opportunity to recover some of the values from the waste and reduces the volume of waste to be managed.

Between reuse and recycling, reuse is a simpler process involving reutilization of material as it is without the necessity of reprocessing, while recycling requires some processing before the material can be used for manufacturing. The processing of recovered material requires economical justification before the reprocessing can be carried out. Use of recycled materials reduces the overall cost of production if recycling can be done economically. For example, the CS group, a private company in Lao PDR recycles plastics to produce polyethylene (PE) pipes for the local market since 1999. These pipes are 50 % cheaper than polyvinyl chloride pipes imported from Thailand. The main use of these pipes is for irrigation.

The company relies on the recyclable plastic from the urban wastes such as plastic drinking water bottles and plastic wastes from hospitals such as syringes and transfusion bottles. Local waste collectors collect these materials from different generation points in the city of Vientiane, Laos PDR and sell it to the CS Company (Ayamuang and Wongpanit, 2000).

Often, the economics of resource recovery is determined by comparing the processing cost against the finished material cost. This can however be misleading, as the reduction of cost of waste handling, transport and disposal (as may be applicable) due to reduction in waste volume should also be considered. One classic example of recycling is that of paper. Waste paper can be recycled and made into cardboard or inferior type paper that can be used for various purposes. Many books are now a day published over recycled paper. Similarly, plastic bags can also be recycled and made into floor tiles (UNCHS, 2000). Plastic bags can also be reprocessed to manufacture inferior quality plastic bags that can be used in packaging industry. In 1990, scavengers and solid waste collection crews recycled an estimated 300 tons/day or 8% of the total solid waste generated in Metro Manila (Chua and Garces, 1992), which shows the tremendous potential of recycling.

G. Collection & Transportation

Collection of waste from different waste collection points (fig 2.6) is carried out by many agents, which represent a variety of organizational structures and relationships. In most developing countries, collection of urban solid waste comes under the auspices of the local municipal bodies who are the main stakeholders responsible for urban solid waste management. These authorities are responsible for waste management within specified boundaries often called municipalities. Sometimes, private sector companies and organizations are appointed by the municipal authorities to assist the local authorities, but private participation is yet not popular. However, small and large private enterprises engaged in reprocessing exist in many countries. Other than private contractors, non-government and community-based organizations (NGOs & CBOs), also assist the municipal authorities in collecting, treating and disposing waste.

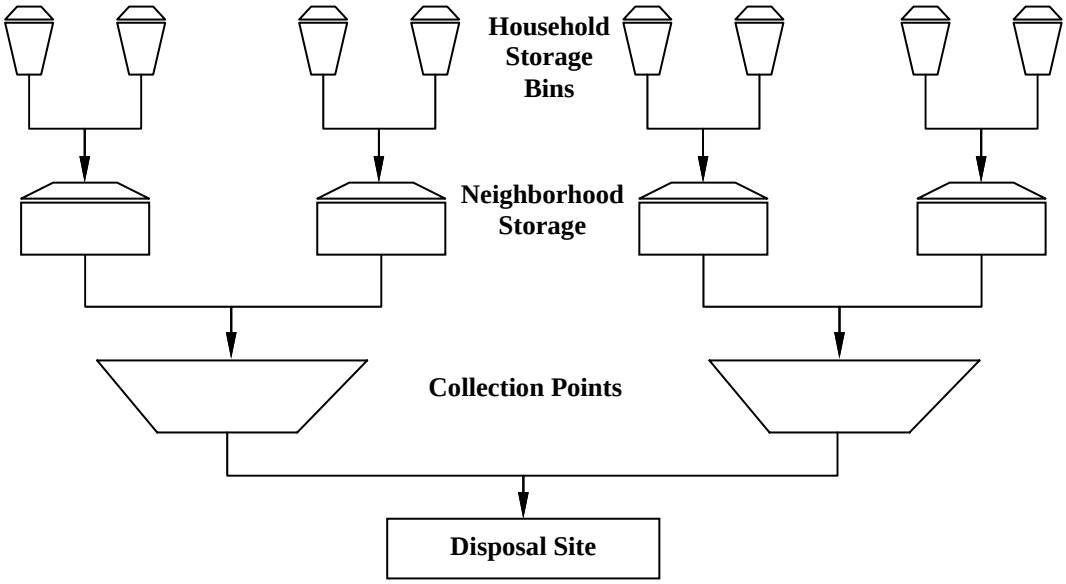

Figure 2.6 Schematic Diagram of Solid Waste Collection Points in Asia and Africa

A significant amount of solid waste that is generated in urban centers remains uncollected or collected irregularly. These wastes infallibly end up in rivers, creeks, marshy areas, water bodies, open public spaces and seas. These wastes are a source of great concern as these can give rise to a number of problems like littering, breeding of insects and contaminating water, land and air. Conditions are sometimes severe in the bazaars (fresh food markets), slums and narrow lanes and by lanes. In Asia, on an average about 70 % (table 2.7) of the solid waste is collected and in Africa collection rate varies form 30 – 70 % (refer table 2.6).

Table 2.7 Solid Waste Generation and Collection Rate in Different Cities of Asia
(Source: Chua and Garces, 1992, Einsiedel, 1998)

City	Total weight generated (tons/day)	Generation rate (kg/per/day)	Bulk density (tons/cum)	Rate of collection (%)
Bangkok	8,000	0.90	0.25	75
Songkhla	-	0.89	0.42	46
Kuala Lumpur	348	-	-	80
Penang	5,000	0.75	0.25	70
Jakarta	4,625	0.50	0.33	70
Manila	2,650	0.65	-	70
Mumbai	5,800	0.55	0.33	86
Calcutta	3,500	-	-	55
Delhi	3,880	-	-	62
Dhaka	3,000	0.50	-	50
Colombo	750	0.75	0.35	90
Karachi	4,500	0.55	-	33

- not available

The main reason for lower collection rate is the lack of infrastructure. In Lusaka, Africa about 1,400 tons of solid waste is generated daily by 1.3 million inhabitants. About 90% of the waste remains uncollected because the local authority does not have sufficient staff, fund and equipment. In most of the cities in the developing countries, handling and transport capacities fall short of the generation rate leading to accumulation of wastes. In Dar-es-Salaam, Tanzania for example, MSW is generated at a rate of about 2,000 tons per day, while the city's removal capacity is limited to 100 tons a day (Mosha 1990) only. In order to tackle the situation, refuse collection is restricted to high-income areas and there are no regular collection services available to other parts and in the squatter areas. Uncollected refuse soon attracts rodents, flies, and other vermins and poses a threat to the health and hygiene of the citizens. The percentage of MSW collection in Nairobi, Kenya is shown in table 2.8. Role of different agencies (private, CBO) in waste collection can be found from the table. The active participation of the private sector in waste collection and transport is note worthy for this city.

Table 2.8 Solid Waste Collection Rate in Nairobi, Kenya

(Source: Johannessen and Boyer, 1999)

Collection Agency	Activity Area			
	Residential	Institutions	Industrial	Commercial
NCC	1(1%)	4 (21%)	-	3 (17%)
Private sector	57 (73%)	6 (32%)	10 (50%)	3 (17%)
CBOs	5 (6%)	-	-	-
Personal Initiative	15 (19%)	9 (47%)	10 (50%)	12 (66%)
Total	78 (100%)	19 (100%)	20 (100%)	18 (100%)

Two separate case studies on implementation of successful collection service are shown in box 2.2 and 2.3, for the cities of Olangapo, Philippines and Wogodogo Municipality, Ouagadougou, Burkina Faso respectively. In both the cases, the importance of community participation and an organizational effort is identifiable. The need for a proper tax structure and recognization of solid waste collection as a separate trade is also understandable from the first case.

Various modes are used for transportation of solid waste from the collection points to the transfer stations and finally to the disposal site. The most common mode of transport is by transfer trucks (fig 2.7a). However, in many low-income cities of Asia and Africa, animal drawn cart and human drawn vehicles (fig 2.7b) are also used to transport solid waste. In many cities, collection is largely affected by inadequate number of transport vehicles, absence of roads, inaccessible sites, traffic congestion and high hauling cost. For example, Metro Manila, Philippines having a population of 9.8 million and an annual growth rate of 5% faces severe traffic congestion. To avoid the most severe traffic problems, transportation is usually carried out between 6:00 pm and 6:00 am. Transfer trucks are primarily used for hauling and delivery of about 1,500 tons of waste per day to the Carmona landfill, 40 km outside Metro Manila. On the other hand, the Metro Manila landfill in San Mateo receives waste during the daytime, with the result that some transfer trucks are held in traffic for more than three hours on their way to the disposal site (Johannessen and Boyer, 1999).

Box 2.2 Solid Waste Collection System in the city of Olangapo, Philippines

Until the late 1980s, the City of Olongapo had no specific ordinances or other legislative measures dealing with solid waste collection. Solid waste was collected in a rather crude and haphazard manner and was often left to private groups or firms; and no service fees were imposed. In September 1989, the City of Olongapo launched the Integrated Solid Waste Collection System under the charge of Environmental Sanitation and Management Office (ESMO). Between 1988 and 1990, the City Council enacted eight ordinances or measures dealing with the utilization of the sanitary landfill area, the rates of solid waste collection fees, the schedules and mechanics of collection etc. Directives and issuances by the Local Chief Executive supplement the ordinances. For residential areas, solid waste is collected twice a week, while in commercial areas it is collected daily.

The approach is pragmatic; the system uses basic and indigenous technology. The sanitary landfill is well kept and maintained to acceptable standards. The drivers of the collection trucks and the sanitary technicians are provided with uniforms to give them dignity and a sense of professionalism. The program is successful due to effective public participation

A social pricing system was adopted for the service fees and charges were based on one's ability to pay. Businesses, professionals and other higher-income groups pay more than the ordinary residents. Fee collection was kept simple by synchronizing the payment for the fee with that of the electricity bill. Citation tickets are issued, if premises are unclean.

The Environmental Sanitation and Management Office currently have an annual budget of Peso 4.0 million (US $ 1 = Peso 50). This includes personnel costs, operating expenses and capital outlay. Prior to the implementation of the system, the city had to subsidize the solid waste collection and disposal services, because no revenue was generated. Now, the ESMO raises 6.0 million peso per year in collection fees.

Because of terrain constraints, the solid waste collection system can serve only 85 per cent of the current city population of 250,000 inhabitants. Some areas are difficult to access for the collection trucks and the municipality has designated collection points.

(Source: Gerlagh, R., Beuking, Pieter Van, Varma, Madhu, Yadav P.P. and Pandey, Preety, March 1999, Integrated modeling of solid waste in India, Working paper No: 26, Institute for Environmental Studies, Amsterdam)

Box 2.3 Waste Collection System at Wogodogo Municipality, Ouagadougou, Burkina Faso

Wogodogo is the capital city of Ouagadougou, Burkina Faso, with approximately 25,000 inhabitants approximately between 1600 to 2000 households. Before 1993, there was no organized collection system of solid waste and disposal by private sector operators involved merely burning or open dumping at the outskirt of the city.

A project by Center Regional pour L'Eae et L'Assainnissement (CREPA) found solution for environmental problem including the neighboring cities and several other countries. First year, the project launched curbside collection by group of women and men. Next year, composting activates on a commercial basis was started.

Later the project modified the transport animal carts to increase the carrying capacity and discharge of waste and built a transfer point for storage, garbage treatment and recycling purpose. The local municipality discharges the waste at transfer point using municipality truck and labors. At this end of the service chain, Municipality and project management has been confronted by a lot of difficulties regarding collaboration with the municipality. The municipality had no intension to serve as requested by the project management due to several disagreement and lack of financial resources. This has proved so far the principal weak point of the project.

(Source: Training Manual on MSW for Africa)

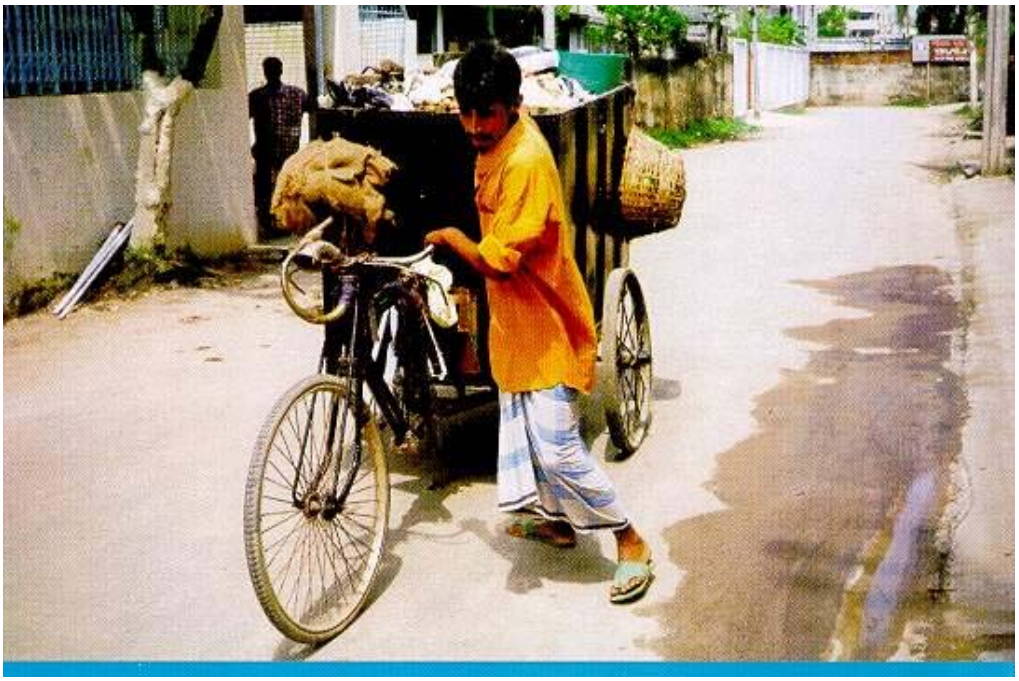

Figure 2.7 Solid Waste Transport by (a) Transfer Truck and (b) Human Drawn Vehicle

H. Disposal

Incineration, composting and landfilling are the three major MSW disposal techniques in Asia and Africa. The waste disposal practices amongst different developing countries differ from each other mainly due to technical, organizational and financial reasons. Similarly, techniques adopted in different cities of the same country may also differ depending on these factors. Various other factors affect the choice of the disposal technique. In many parts of Asia and Africa, the collected waste is simply dumped in some open fields at the outskirts of the city. In these cases, the waste is practically untreated and often, hospital waste is mixed indiscriminately with industrial and domestic waste. This open dumping (fig 2.8) approach is by far the predominant waste disposal technique in many developing countries of both the continents. For example, in India, more than 90% of the solid waste is disposed in open dumps, and in Nigeria about 70% is dumped at the riverside or into nearby rivers and streams (Nwaka, 1990). Table 2.9 lists the different techniques used in some countries for MSW disposal. Each of these techniques is discussed below.

Figure 2.8 Open dumping of Solid Waste

Table 2.9 Disposal Methods of MSW in Different Asian Countries
(Source: Einsiedel, 1998)

Country/ Territory	Disposal method (%)			
	Land disposal	Incineration	Composting	Others
Bangladesh	95.0	-	-	5.0
Brunei Darussalam	90.0	-	-	10.0
Hong Kong	92.0	8.0	-	-
India	70.0	-	20.0	10.0
Indonesia	80.0	5.0	10.0	5.0
Japan	22.0	74.0	0.1	3.9
Rep of Korea	90.0	-	-	1.0
Malaysia	70.0	5.0	10.0	15.0
Philippines	85.0	-	10.0	5.0
Singapore	15.0	85.0	-	-
Sri Lanka	90.0	-	-	10.0
Thailand	80.0	5.0	10.0	5.0

Landfill

In this technique (fig 2.9), the solid waste is placed over the land and left to the nature for transformation of the organic and biodegradable portion to humus. There are three types of landfill operations being practiced in Asia and Africa namely, open dump or open landfill, semi controlled or operated landfill and sanitary landfill. The first technique is the most primitive and crude one, whereas sanitary landfilling is the best among the three. In comparison to Africa (where more open dumping is practiced), awareness about proper landfilling techniques and its importance is found to be more in Asia. As a result, more and more sanitary landfills are used and gradually, existing open landfills are converted to sanitary landfills. In spite of such trend, today the majority of the landfills are still open dumps.

Figure 2.9 Typical Landfill Operation Site

Open dumps involve indiscriminate disposal of waste on the disposal site with practically no measures or at the most limited measures to control operation and maintenance of such landfills. This causes nuisance and several social and environmental impacts and can even cause health threats to nearby population. As cities grow and produce more waste and their solid waste collection system improves, the environmental impacts from open dumps become increasingly important. Efforts are underway through out the region to eliminate open dumps.

An operated or semi-controlled dump is the next stage of upgraded landfill. These are a compromise between the open dumping and sanitary landfills. Semi-controlled dumps have some form of inspection, recording and monitoring arrangements. In some of these landfills, compaction of waste at the control points and/or the tipping stations is practiced. In some of these landfills, soil cover is applied but only limited measures are taken to mitigate other environmental impacts from release of leachate and landfill gas.

Conversion of open or operated dumps to engineered landfills and sanitary landfills is one of the important steps towards better disposal practices. Operated landfills reduce the impact of landfilling over the environment and public health but cannot eliminate it.

The term sanitary landfill is generally applied to landfills, where waste is compacted and daily soil cover is applied over the placed waste to isolate it from the environment. The soil is prepared before the waste is placed and often, leachate and gas collection devices are installed to avoid contamination of ground water and air. When the landfill is designed to have liners (to protect the soil from contamination) and gas and leachate treatment techniques are installed it is referred to as engineered landfill. Application of soil cover limits growth and activities of vermin, flies, animals and birds. It also reduces the odor, caused by the decomposition of the organic part of the waste. About 50% of the operational budget of a sanitary landfill is consumed in daily cover even though daily cover is applied limitedly.

Landfill is considered a reliable and cost effective method for solid waste disposal in developing countries. These are specially attractive in developing countries where land and labor is relatively cheap, capital and operational budgets are limited and advance technology is not available or costly. Sanitary landfills are therefore recommended for developing nations of Asia and Africa where project cost is limited. In China alone, construction of 1000 sanitary landfills are proposed in the next 10 years. In South Africa, a large number of reasonably well-designed and well-operated sanitary landfills are being constructed and operated during the last decade. Some countries have developed their own standards pertaining to landfills. One of such cases is given in box 2.4 for South Africa, where landfills are classified according to the waste type and size of the waste stream.

A number of characteristics distinguish a sanitary landfill from a semi-controlled dump, although these characteristics vary from region to region, from nation to nation, and even from site to site. Table 2.10 lists few distinct characteristics of the different types of landfills in Asia.

Box 2.4 Classification of Landfills according to Waste Types*

The minimum requirements classify landfills according to :

Waste types: General waste (primarily non-hazardous solid wastes); or hazardous waste (rated according to degree of hazard);

.

Size of waste stream: Communal sites (1-25 tons per day), Small (25-150 tons per day), Medium (150-500 tons per day) and Large (>500 tons per day);

.

Climatic water balance: Significant leachate generation (in wet areas, where leachate collection and treatment is required) and no significant leachate generation (in arid and semi-arid areas where leachate collection is not required).

*Stringency increases with hazard ness of waste, size of the landfill, and possible leachate generation.

(Source: Johannessen, Lars Mikkel and Boyer, Gabriela, June 1999, Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America Urban Development Division Waste Management Anchor Team, The World Bank)

Table 2.10 Characteristics of Different Types of Landfill

(Source: Johannessen, and Boyer June 1999)

	Engineering Measures	Leachate management	Landfill Gas management	Operation Measures
Semi-Controlled Dumps	None	Unrestricted contaminant release	None	Few, some placement of waste- still scavenging
Controlled Dump	None	Unrestricted contaminant release	None	Registration and placement/ compaction of waste
Engineered landfill	Infrastructure and liner in place	Containment and some Level of leachate treatment	Passive ventilation or flaring	Registration and placement/ compaction of waste; uses daily soil cover
Sanitary landfill	Proper siting, infrastructure; liner and leachate treatment in place	Containment and leachate treatment (often biological and physico-chemical treatment	Flaring	Registration and Placement / compaction of waste; uses daily soil cover. Measures for final top cover
Sanitary Landfill with Top Seal	Proper siting, infrastructure; liner and leachate treatment in place, Liner as top seal,	Entombment	Flaring	Registration and placement/ compaction of waste; uses daily soil cover
Controlled Contaminant Release Landfill	Proper siting, infrastructure, with low-permeability liner in place. Potentially low-permeability final top cover	Controlled release of leachate into the environment, based on assessment and proper siting	Flaring or passive ventilation through top cover	Registration and placement/ compaction of waste; uses daily soil cover. Measures for final top cover

In spite of ease in construction, operation and maintenance, post closure of sanitary landfills can be a major issue. Post closure activities involve monitoring of landfill gas and leachate after the landfill is closed (when its capacity is reached). Absence of post closure care to landfill is considered as one of the major weaknesses for most landfill management systems in Asia and Africa. Post closure management of landfill requires technical and management skills that are often not available in some of these countries. In most of these cases, post closure monitoring is neglected and not cared for, resulting in groundwater contamination and land subsidence.

The costs associated with landfill are construction and operation of landfills, post closure monitoring of gas and leachate and leachate treatment. Though cost of landfill can be less than cost for other types of disposal techniques, however, very limited budget can pose difficulties to operation and maintenance and post closure monitoring, thereby reducing the quality of the landfill. Several examples can be found about failure of such projects due to lack of technical, management or financial planning. For example, the Mobeni landfill in Durban, South Africa was equipped to receive both hazardous and industrial waste for co-disposal with MSW, but it collapsed in November 1997 due to poor design and operation. In another instance, the Mpewere landfill, in Uganda was inaugurated in 1995 for disposal of MSW. The operational difficulties caused the landfill to revert to an open dump within a year of opening (Mosha, 1990). A case study is presented in box 2.5 showing how operational and financial difficulties lead to failure of sanitary landfills, which is now being used as open dump.

Engineered landfills require liners like compacted clay, plastic, betonite and concrete for controlling solid waste within the landfill site to avoid ground contamination. Electrically powered aerators are used commonly for treatment of leachate. However, regular monitoring of the leachate composition before and after leachate treatment is rarely carried out and

Box 2.5 Landfill Operated as Open Dump, Jakarta, Indonesia

The Jakarta landfill, Bantar Gebang, was designed and constructed with proper lining, leachate collection and treatment mechanisms. As electric power costs are high, only one of the two aerated lagoons is under full operation. The landfill is equipped with 3 compactors, 18 bulldozers, 4 excavators, 17 wheel loaders, and 3 trucks. At the tipping front, only few bulldozers grade the waste. Equipment such as bulldozers and compactors are not used, as landfill budgets could not cover their operation. The landfill had several fires at the tipping fronts and in areas where landfilling had been inactive. Approximately 640 registered waste pickers were present at the landfill.

(Source: Johannessen, Lars Mikkel and Boyer, Gabriela, June 1999, Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America Urban Development Division Waste Management Anchor Team, The World Bank)

therefore the efficacy of the leachate treatment methods is doubtful. Landfill gas containing mostly carbon dioxide and methane is produced at different layers of the placed waste as a result of biodegradation of solid waste. In many landfills, landfill gas is released directly to the atmosphere by installing vertical gas wells, a method referred to as passive ventilation. A

large amount of gas can be released during the active state of landfills due to high activity rate during early years. Uncontrolled release of the landfill gas can be harmful for the atmosphere as it contains methane that is known to promote global warming through the greenhouse effect. The combination of methane and carbon dioxide can also be explosive and in many cases, explosion and fires are caused in the past due to inadequate ventilation. In some landfills the gas is burned in flares before releasing to the atmosphere while in few others, the gas is utilized for energy recovery. Lack of coordination and financial incentives and difficulties in contractual arrangements with the power companies often restricts the use of landfill gas for power generation.

Lack of monitoring devices for measuring landfill gas and leachate is another drawback in many landfills in Asia and Africa. It has caused some severe environmental impacts, like ground water and surface water contamination and accidents, caused by explosion, open fires and land subsidence. Figure 2.10 illustrates schematically the long-term environmental impacts, how they are generally perceived and the costs involved in controlling them.

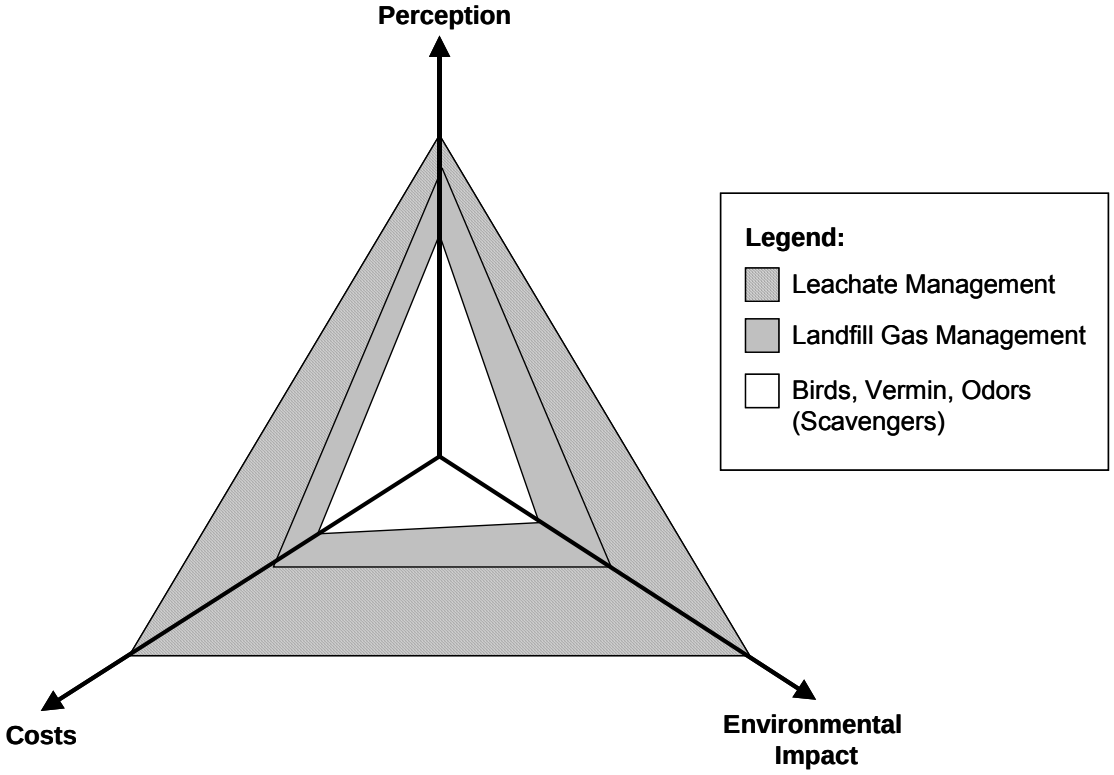

Figure 2.10 Landfill Triangle for Assessment of Long-term Impacts

In this framework, the cost does not include the cost of land. However, leachate management includes all costs related to leachate collection, treatment and disposal, until it no longer poses a threat to the environment. The figure shows how perception and measured impacts on the environment and cost differs from each other. For example, the long-term environmental impacts from birds, vermin, and odors are negligible in comparison to the possible pollution of leachate and the landfill gas but the perception about it is quite different.

Composting

Composting is the process of natural conversion of biodegradable (organic) portion of the solid waste to a stable product called compost, under controlled condition. Compost is a natural product enriched with different essential elements and compounds that can be very suitably used as a fertilizer, thereby opening the possibility of value addition. Composting is particularly favored in hot and humid climate, which accelerates the rate of biodegradation. Composting is also very popular in many Asian and African countries, but is comparatively more popular in Asia. Normally, the organic portion of the MSW is separated from the inorganic portion and is subjected to composting. Composting can be mechanized, which involves machineries for handling the waste and controlling the conditions of the composting. It can be semi mechanized also in which much less machineries are required and natural processes are promoted. Common example of semi mechanized composting is windrows and barrel composting. However, semi mechanized composting is used more for small scale composting plant.

In the past, many large cities (like Bangkok, Thailand, Hanoi, Vietnam, Tokyo, Japan, New Delhi and Bombay, India) of the developing countries installed imported large-scale mechanical composting plants. However today, most of these plants (fig 2.11) are either defunct or are not operating to their full capacity. Failure of these centralized mechanical composting plants are mainly due to poor operation and maintenance arising from lack of skilled operator and operator's negligence, high operating and maintenance cost and incomplete separation of inorganic material like plastics and glass, which reduces the quality of the compost rendering them unfit for agricultural use. Moreover, the downstream market for selling compost was not developed and the cost of compost remained higher compared to other commercial fertilizers, thereby further losing market share.

Figure 2.11 Large Scale Composting Plant

On the other hand, many small-scale community-composting plants (fig 2.12) installed close to the vicinity of the community has found to be quite successful in the developing countries. Such plants use simple techniques such as windrow composting or barrel composting that are easy to operate and maintain and are low cost systems that proved to be more suitable for many low-income nations. In Bangladesh, several such composting plants have been operating successfully. One of the cases is presented in box 2.6 and fig 2.13 shows schematically the steps involved in such composting plants.

Figure 2.12 Solid Waste Composting Plant in Bangkok, Thailand

Box 2.6 Small scale Community Composting Plant in Dhaka, Bangladesh

In an attempt to capture the value of organic waste, to create job opportunities for the urban poor and to develop business opportunities for the local entrepreneurs, " Waste Concern", a national NGO of Bangladesh, has initiated a decentralized community-based organic resource recovery and composting project. This small-scale composting project started its operation in January 1995.

On a 1000 m^2 land, Waste Concern processes 2 tons of solid waste per day from which about 400 kg of compost is produced. One thousand households of Mirpur section-2 of the Dhaka city have been included in the composting project. Modified rickshaw vans collect the waste from house to house, and the households pay Bangladesh Taka 15 per month (US$ 1 = Taka 50) for this service. The waste is separated and sorted at the composting plant located within the community and processed into compost using manual aerobic techniques. The whole process of composting is free of odor or other nuisance.

The production cost of compost using the manual aerobic technique is Taka 1.65 per kg (excluding the land rent). The market price of compost sold in Dhaka is between Taka 10 to Taka 18 per kg. Waste Concern sells its compost to a local fertilizer company at a price of Taka 2.50 per kg. This project demonstrates that a small-scale community-based composting plant can be a commercially viable and self-sustainable project. Waste Concern, has plans to expand the operation to three other communities in the Dhaka city, capital of Bangladesh.

(Source: Report on Seventh Meeting Of The Urban Think Tank 'Effective Solid Waste Management With The Participation Of Waste Producers', Water and Sanitation program, January 1999)

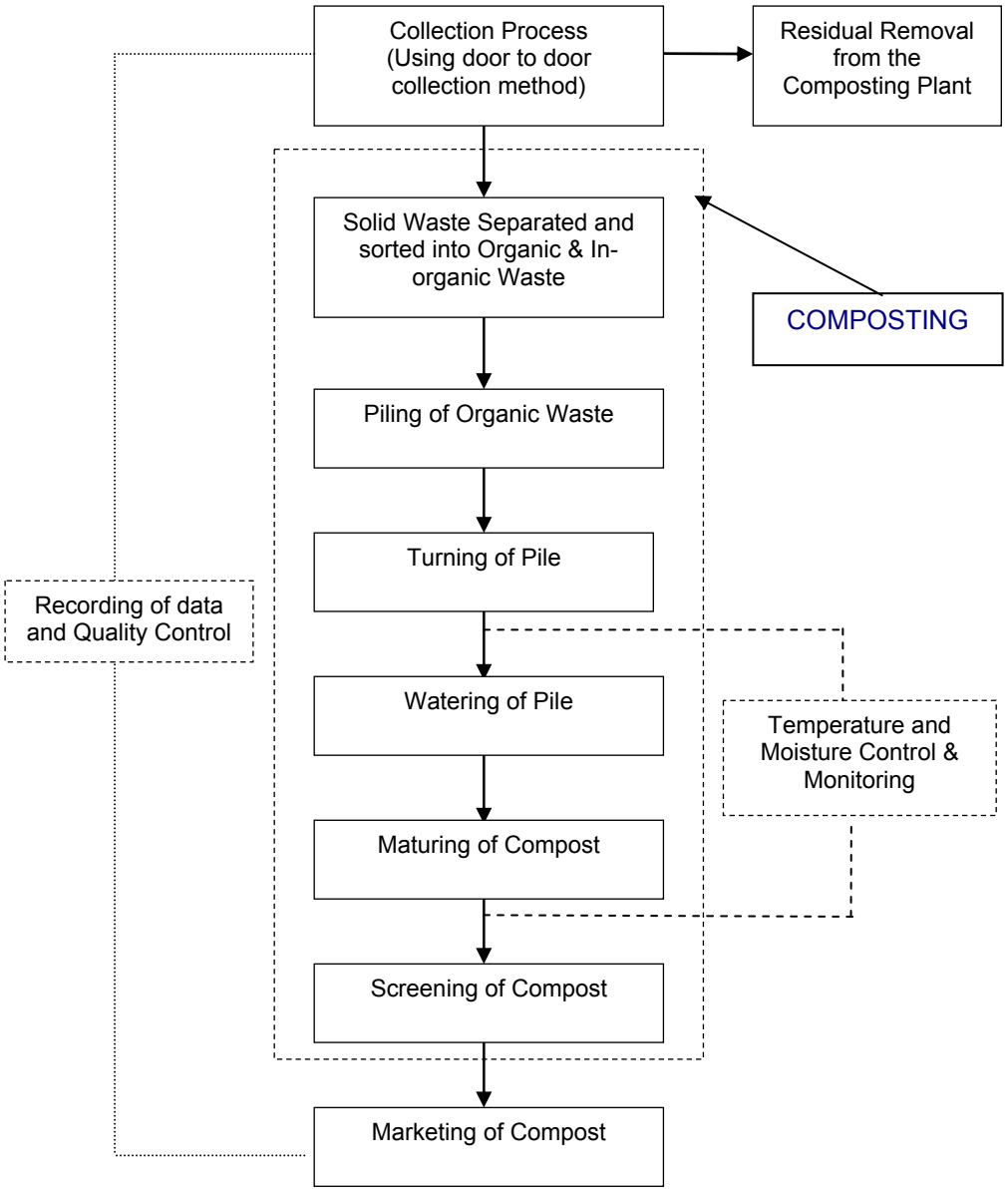

Figure 2.13 Schematic Steps in Small-scale Composting
(Source: Report on Seventh Meeting Of The Urban Think Tank, 1999)

Composting of MSW in Africa is not as common as in Asia though there are small scales composting plants in some of the countries operating at the local level. Most of these projects are funded by the NGOs to promote composting at the community level that can be used as an economic tool to generate income out of solid waste. One of such efforts (box 2.7) illustrates replacement of incinerator by local composting plant, since the incinerator failed to perform under the local condition.

Box: 2.7 Composting in South Africa:
Lagos State Govt. to Set Up Composting Plant to Combat Waste

Lagos, the former capital city of Nigeria with a population of about 10 million people is planning to set up a composting plant, which will be used to process its organic wastes currently discarded indiscriminately.

Towards this end, a small scale pilot composing plant scheme for composting the organic waste has been set up by the Lagos State Environmental Protection Agency an organ of the government set up to control and monitor the Lagos environment.

Over the years, previous governments have been having problems on what to do with wastes generated in Lagos state. Many technologies of the first world, which were not adaptable to local situations, were used. About a decade ago, one of the governments installed many gigantic incinerators at a cost of $45million from an Italian firm. However, the incinerators did not work for one day because it was later discovered that the plants could only treat garbage containing less than 20 per cent water whereas the Lagos garbage contains 30-40% liquid.

(Source: Tunde Akingbade, Global South, An Independent Monthly e-Journal for Global Interdependence < http://www.globalsouth.org/AFRICA CALLING/lagos state.htm >*)*

Composting can be very suitable in treating solid waste from hotels as these wastes contain a high amount of organic waste, yard waste and papers that are easily compostable. The compost can then be used as fertilizers to landscape the hotel premises, lawns and gardens. Many such initiatives have been taken in Thailand and other countries where tourism is developed and large number of hotels is situated within the cities and other tourist spots. One of such cases from Japan is given in box 2.8.

Box 2.8 Composting Hotel Waste, Tokyo, Japan

The New Otani hotel in Tokyo produces 5 tons of waste each day. In mid 1990s, the hotel was paying 248,000 USD a year to the government to incinerate the waste and the costs were rising every year. Bad odor was another problem that initiated the concerned owner to take the initiative for composting. The kitchen waste, sludge produced from the water recycling system, old flowers from the banquet rooms and the excess steam in the hotel is turned into useful fertilizer. The hotel's food recycling machine outpours 700 Kg of high quality fertilizer base. A biotech company, which buys this base, composts it, then sells to the farmers, and supplies the compost to the hotel for its own landscaping activities. The hotel expects to make back the initial investment within 4 years and continue to make profit after that.

(Source: Lietmann, Josef, April 2000, Integrating the environment in urban development: Singapore as a model of good practice, Singapore as a model of good practice. Working paper series No: 7, Published for the Urban Development Division, World Bank)

The success of a composting plant depends on the market where it can sell the compost. Therefore, it is necessary to create a market for the compost products in order to explore the potential of value recovery from the compost. Market research, training, market development and promotion of awareness have found to contribute to the success of such projects. It is found that a better approach would be to study the demand of the compost in the market and create market opportunities for compost before building composting plants. The distribution networks of the fertilizer companies can also be used to promote market for the compost as is increasingly practiced in USA now a days (UNCHS, 2000).

In one of such efforts in 1992, the Jakarta (Indonesia) city government set-up several small scale composting units in order to enhance the role of private sector. The project was aimed to train individuals about composting and train intermediate buyers of the recyclable wastes to stimulate the market. In 1994, an assessment of the project showed that composting resulted in reduction of waste and contributed to the improvement of the neighborhood environment. Critical success factors were good management, market research and consistent support the institutions (Einsiedel, 1998).

Vermi Composting

Parallel to the conventional composting method alternative methods are also studied recently, to improve the efficiency and techniques of composting. One of such techniques is the use of earthworms for composting. The culture of earthworm is known as “vermiculture”, which is a very active creature in soil conditioning. The aim of vermin composting is to get humus (the end product) as well as new worms to be used in agriculture. The humus enriches the soil and the worms improve the soil structure. The composting process takes about 3-4 weeks to get the final products. The harvested earthworms can also be used for poultry and fishing ponds as animal and fish food.

In 1991, Waste Wise a NGO in Bangalore, India started a project on decentralized MSW management approaches by creating a number of citizen groups as well as waste pickers who were formally involved in managing waste of the households. The goal of the project was to convert the organic portion of the municipal garbage into compost, as close to the waste generation points as possible to reduce the transport costs. In one of such studies, earthworms were used successfully at both the household level and the municipal level to hasten the process of composting and to eliminate the malicious odor of decaying garbage.

After the success of such project, several other projects have been taken up. The detail of such technique is presented in box 2.9.

Box 2.9 Vermicomposting as a mean of MSW Composting in Bangalore, India

The task was undertaken along with experts from University of Agriculture, Bangalore (UAS), the Karnataka State Council for Science and Technology (KSCST), several solid waste management experts and others related to urban planning.

A small piece of land for treatment of garbage on experimental level was obtained from the Bangalore City Corporation in a park near the service area. Phase II of the project resulted in establishment of Vermi Compost Grove in the park area. The purpose was to develop a suitable vermin compost technique for the city of Bangalore. Cost benefit study associated with the scheme was also performed. By 1994, the pilot project operated for about 400 households. Approximately 250 to 300 kg of wet organic waste and 20 - 25 kg of dry waste was collected from the households every day. Unsanitary wastes were collected once in a week and burned. Dry wastes like paper, plastic, metals and glass was stored for a week by the waste pickers and sold in bulk to the regular outlets.

The wet garbage was transported from households to park area by hand driven trolleys and dumped in an open pit measuring 3m x 1.5m having a depth of 0.75 m. It was covered with dry leaves or other materials. The waste was allowed to decompose for ten days with regular turning on alternate days. After 10 days, the partly decomposed organic matter was transferred to another closed pit of the same dimension. The second pit had a roof made out of mild steel to prevent excess sunlight and water during rainy days. The pits were covered with wire mesh to prevent rodents, stray dogs and cows.

The vermiculture was developed by the UAS, comprising of selected species of the earthworm family. The vermiculture was introduced into the second pit and garbage was kept moist by adding water. About 30 days were required for the conversion to be completed with regular turning of the garbage, every three days. At the end of four weeks, the compost consisted of worm castings as well as finely broken down particles of organic materials. It was then made into mounds and allowed to remain for about 24 hours. During this time, the worms move to the bottom of the pit and the compost is skimmed from the top. The compost was then sieved to remove juvenile worms, cocoons and other undigested compounds. The sieved material was stored in one part of the park to be used as the covering material for the fresh garbage. The sieved vermin compost was packed in 1 to 50 kg plastic bags and sold to nurseries, florist, landscapers, home gardeners and small farmers

(Source: Rosario, Anselm, 1994, Decentralized solid waste management approach, 20th WEDC Conference: Colombo, Sri Lanka)

Incineration

In this technique, the solid waste is burnt at a very high temperature (900 to 1200 °C) under controlled condition. The result of incineration is residual ash having a weight of around 8 – 10 kg per 100 kg of solid waste. The technology has been developed quite a lot in the western countries, who are the main supplier of incineration plants. The range of incineration technologies available today is very wide. However, there are several environmental impacts from incineration (release of Dioxine and other toxic gases), which must be addressed for proper use of the technology. The technology requires a high capital and operating cost and skilled operators but a small piece of land to setup. The technology is typically unaffordable in many cities having a limited budget for MSW management. Today, incineration is not allowed in several cities of the western countries owing to the severe potential for air pollution.

Even though incineration is used in the industrialized countries like Japan, Singapore, South Korea, Taiwan and Hong Kong it has not been successful in the developing countries. In many cases, the imported technology did not suit the characteristics of solid waste or the climatic condition and was not the appropriate technology. One of such failures is given in box 2.7 for Lagos, Nigeria. In another case, in New Delhi, India an incinerator was built in 1980s by the Delhi Municipal Corporation using Norwegian Technology. The incinerator had been idle after the trial runs. It had not been able to process wastes because the calorific value of the waste was too low to support self combustion, thereby requiring a large amount of supplementary fuel to maintain satisfactory temperature. The operating cost was found to be much higher, rendering the system uneconomic. Delhi officials complained that the rag pickers were responsible for lowering the calorific value of the waste by removing woods, paper, plastic and other high calorific wastes, which makes the incinerators inoperable.

High operational and maintenance cost also deters the use of incinerators. For example, in the Quezon City (Philippines) an incinerator was built in the late 1960s. It operated for only a few months before it was stopped, as the city authority could not afford to have the incinerator repaired when it broke down due to a design defects. In another case, the local municipalities in Phuket, Thailand were unable to operate the incinerators due to high operational cost. Among other factors, the climatic condition affects the performance of the incinerator. High humidity and rainfall increases the moisture content in the solid waste making it unsuitable for incineration (refer box 2.7).

Incinerators are particularly suitable where land is limited. Incineration has been a success in Singapore, which has strict environmental protection rules and regulations. Three incineration plants were installed in Singapore in 1991 that could handle about 85% of the waste and the remaining 15% was disposed off at sanitary landfills. Overhead grab cranes feed the refuse into the incinerators. After incineration, the residue goes through overhead magnetic separators, which pick up the scrap metals. The ash is transported to the dumping ground while the recovered scrap metal is sold to a steel mill for recycling. The heat from incinerators is used to generate steam and used to drive a turbine generator to produce electricity. Part of the electricity generated is used to operate the plant and the surplus is sold to the Public Utilities Board.

To prevent air pollution, equipment such as electrostatic precipitators has been installed to control dust and smoke emissions. Years of experience in the operation and maintenance of incineration plants have trained the engineers to operate the plants under tropical conditions (Source: Waste Management in the Coastal areas of the ASEAN region, 1992). The case is a typical example of success of incinerators in the tropical countries. However, because of its sensitiveness to the composition of waste and the climatic condition, incinerators are not suitable for some tropical climates and composition of waste and these local conditions need to be considered before implementing incinerators.

Anaerobic Digestion

Anaerobic digestion is another way of treatment of solid waste. Anaerobic digestion is a biochemical process that occurs in the absence of dissolved oxygen wherever high amount of wet organic matter accumulates. Anaerobic digestion is a natural process but differs from composting, which is an aerobic (requires oxygen) process. The anaerobic microorganisms convert the organic material into carbon dioxide, new cells, water and methane that can be collected and used as gaseous fuel. The stabilized soil residue (mainly undigested materials and microorganism), which is about 40 to 60 % by weight of the feedstock, can be used as soil conditioner. It also aids landfilling by removing problematic organic waste materials that are responsible for gaseous and liquid emissions. Anaerobic digestion is carried out in enclosed tanks that allow a large portion of the biogas to be collected unlike landfills, where only 30-40 % of the gas generated can be recovered.

A number of systems have been developed to anaerobically treat MSW. There can be different combinations like wet or dry processes, batch or continuous processes, single step

or multi step processes and co digestion with animal manure. Many anaerobic treatment plants for MSW are in operation throughout the world. Many plants are situated in Europe, designed to suit the climatic condition and waste characteristics of Europe.

Construction of large-scale industrial waste processing plants in Shilou, China (17,000 tons/yr) and Bangkok (14,000 tons/yr) were started in 1998. Some small-scale processing plants (less than 2000 tons/yr) are operating in India. The Indian Vanaspati Kachara Bio-gas Plant is one such plant, which uses anaerobic digestion for household refuse and plant waste to produce biogas. Other plants like the Garbage Gas Manure pilot plant in Bardoli, India is established under the initiative of Agricultural Tools Research center. An anaerobic digestion facility (multi stage system) was developed in the city of Anyang, Korea due to the unavailability of land for landfill. Composting was not effective due to high moisture and salt content in the food waste. Anaerobic digestion was found suitable and this facility is processing about 3 tons of organic waste per day. About 230 cum of biogas, 100 kg of humus and 2 tons of wastewater are produced (Aborjona O Paribesh, 1999) from the 3 tons of solid waste. In Sri Lanka, a new type of anaerobic digestion plant using market waste. The plant is found to be 55 – 65% efficient in converting garbage into bio-fertilizer while producing biogas (Jayamanne, 1999).

Many economic factors influence the success or failure of anaerobic digestion plants like energy prices, energy taxes, renewable energy policy, land prices, labor costs, construction and material costs, markets for the compost/soil conditioning product and prices and quality of the compost produced. In Europe, the system is well developed and is competitive. However, production scale affects the cost of production. According to the data of 1996, a plant with processing capacity of 100,000 tons/yr has a treatment cost less than US$ 30 per ton whereas a plant with a capacity of only 20,000 tons/year has a treatment cost of about US$ 60 per ton. This indicates that the processing capacity have to be large enough in order to render compost at a competitive price.

There are several problems associated with anaerobic digestion of MSW (Aborjona O Paribesh, 1999). The nature of organic waste may vary according to location and time of the year. This may lead to a variation in the carbon to nitrogen ratio and affect the rate of reaction. Inadequate mixing of refuse and sewage can also affect the efficiency of the system. Anaerobic systems are very sensitive to operating condition and therefore any disruption in the operating conditions can lead to partial or complete failure of the system.

Disposal Site Location

Location of disposal site is one of the most important aspects in the solid waste management system. Location of site requires a balance between several technical, economical and social factors, one of the most important of which is the strong “Not in My Back Yard” (NIMBY), attitude of the public. Some other factors include land scarcity, social impacts on nearby residential area, safety and sanitation. With increasing rate of urbanization, the demand for land is increasing and the Asian and African cities are becoming more congested. The cost of new landfills is increasing due to higher cost of land and cost of haulage as a result of scarcity of land near the city.

The presence of the rag pickers near or surrounding the dumpsites/landfills is also one of the important issues that have to be taken into consideration while choosing the site for waste disposal. Waste pickers are migrants from rural areas who come to the urban areas in search of employment. Therefore, they tend to settle near the landfill sites. All sorts of small-scale waste recycling plants and waste recycling businesses also develop in and around the landfill. This spoils the environment of the locality and reduces the safety and security of the area.

In one case, waste pickers use to burn the solid waste to recover metals and other non-combustible materials. A number of severe health problems have been observed among the waste pickers due to air pollution. Therefore, the site must be chosen in such an area that it have a least impact on the nearby residential area. The site is best situated in an isolated place as far from the as possible from the commercial and residential area, with due consideration to the haulage cost.

I. Resource Recovery and Recycling

Different actors and stakeholders are involved in the resource recovery and recycling sector. While in the western countries this is mainly carried out by the private sector, in the developing countries of Asia and Africa both formal (registered and recognized by the municipal authorities) and informal sector (not registered with the authorities) play active roles. Waste pickers, Itinerant Waste Buyers (IWBs) and middlemen such as junk dealers and wholesalers are the main actors of the informal sector though several others (like Own Account or self employed workers, unpaid family members) may be involved. Some of these actors are registered while the others are associated with the sector informally. Involvement

of the private and the informal sector in resource recovery and recycling activities is much more compared to other activities of MSW management due to greater possibility of earning.

In most of the cities in Asia, this sector is monopolized by the lowest economic level of the society. Resource recovery and recycling provides these people an opportunity to earn their livelihood and therefore different trades have developed around waste sorting and resource recovery.

Often a definite hierarchy among these different actors can be noted that creates an opportunity of earning for practically all the people involved in the sector. The popular items of recovery and recycling are polythene bags, newspaper, glass bottles, tins and plastic cans, old wood, old clothes, shoes, rubber and leather products. A schematic diagram of different stages of resource recovery, carried out in Bangkok, Thailand is shown in Figure 2.14.

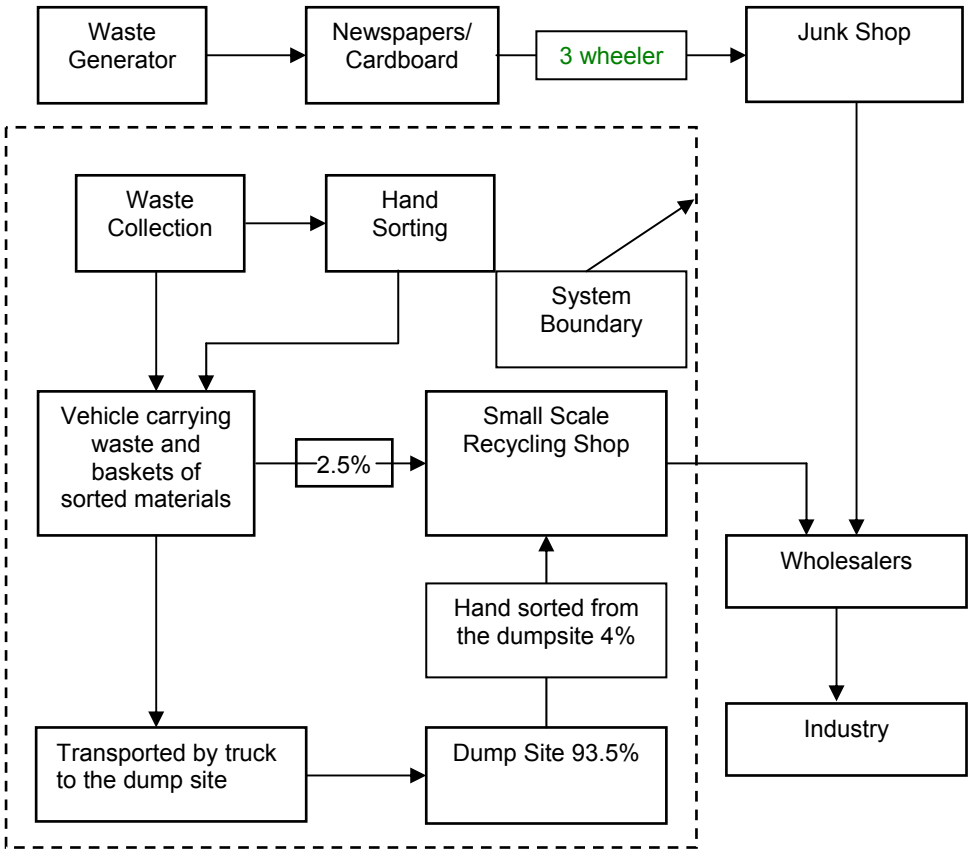

Figure 2.14 Schematic Diagram of Resource Recovery in Bangkok
(Source: Chua and Garces, 1992)

Newspapers, cardboard, glass and metals are collected from door to door in 3-wheeler carts in Bangkok. The household earns by selling these items. The collected materials are then

cleaned, sorted and sold to the scrap or recycling industries. Waste collectors sort saleable materials (wet plastics, papers, metal cans, waste clothes, furniture etc.) from refuse at the collection points during collection. These materials are kept at the sides of the collection vehicles. It is found that about 30-50 % of the collection time is wasted due to this activity.

About 200-500 families living near the dumpsites and transfer stations scavenge the waste upon arrival. These are sold to the scrap buyers who partially process the materials (sorting, cleaning and drying) for further selling. Many middlemen buy the material and sell it to the wholesalers who return it back to the primary industries. (Chua and Garces, 1992). Figure 2.17 shows photographs of scavenging operation and scavenged material from a dumpsite in Bangkok. A case study on resource recovery for Metro Manila, Philippines is given in box 2.10 and the schematic diagram is presented in fig 2.18 showing the different types of waste recovered and the routing of these items. Resource recovery and recycling system reduced the waste volume by about 60 – 70% (UNCHS, 2000).

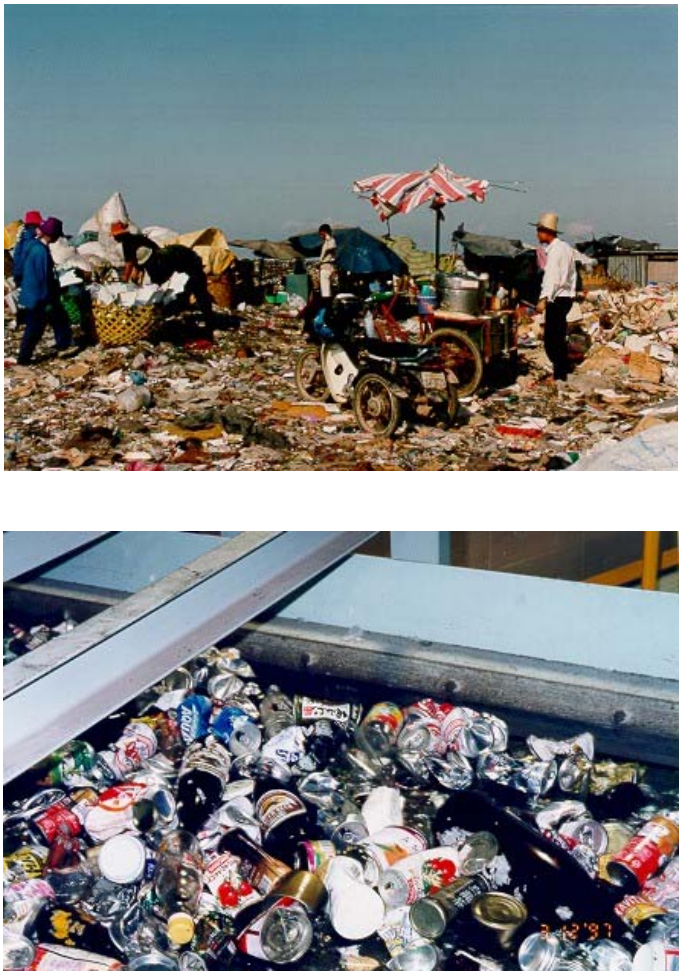

Figure 2.15 Scavenging Operation and Scavenged Material from a typical Dumpsite

Box 2.10 Resource Recovery and Recycling in Metro Manila, Philippines

Metro Manila comprises of five cities and twelve towns with a combined population of more than 1,500,000 households. The estimated solid waste produced by the almost 8 million inhabitants of Metro Manila and 2 million transients is estimated at around 3,500 tons per day. The government started a recycling program by organizing environmental cooperatives, one for each city or town. Each cooperative was registered with the Cooperative Development Authority. The 17 cooperatives had about 890 junkshop owners as members in total, who employ more than 1,500 junk collectors or eco-aides.

Each collector bought waste paper, plastics, bottles, cans and car batteries from the households and schools. The collected materials are sold to the junkshop owners. Each collector earned about Peso 100 to Peso 300 per day. The junkshop owner sorts the items and sells these to paper, plastic, bottles and can factories

Special shredders are available to cut rubber materials such as shoes and slippers after which they are given to the Department of Public Highways for mixing with asphalt. Coconut shells, mats, wood, construction debris and fallen trees are converted into green charcoal. Through a special arrangement with tire factories (Goodyear, Firestone and Sime Darby), old tires are sold to them for recycling. About 300,000 old tires are anticipated to be collected per year. This recycling system reduces the pressure on the dumpsites by at least 60 – 70%.

(*Source: UNCHS, 2000,Resource Recovery Program in Metro Manila, Philippines, Best practices database, http://www.bestpractices.org)*

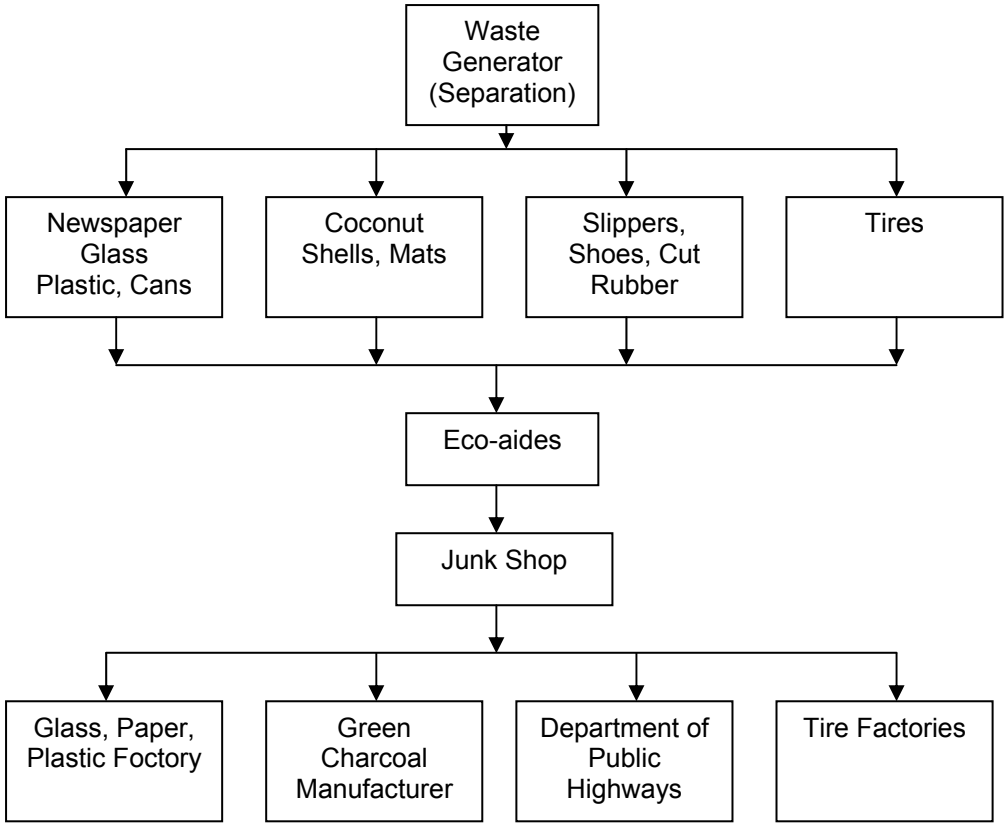

Figure 2.16 Schematic Diagram of Resource Recovery in Metro Manila, Philippines.

(Source: UNCHS 2000)

Community awareness plays an important role in resource recovery from waste. Several studies indicate that by improving community awareness, much can be achieved. For example, in a primary school in Phitsanulok, Thailand a waste bank project has been conducted, where school children bring recyclable materials from their home and deposit at a collection point in the school. The items are sold time to time and a part (60%) of the income is distributed amongst the school children. The rest is kept in the school fund. The aim of the project is to educate young people to appreciate the value of waste recycling, take responsibility for a clean environment and use their spare time in a fruitful way (http://www.makingcitieswork.org/archive.asp).

Resource recovery and recycling can provide opportunity to the poor and old women to earn their livelihood and support their families. One of such cases is the Mukuru Project (Kathrin Senner, 2001). Dandora waste dumping ground is the main dumpsite of the city of Nairobi, Kenya. Some 2000 people, including men, women and children, are living and working at the dumping ground. In 1991, two priests of the Kariobangi Catholic Church initiated the Mukuru Project to help women earn their livelihood and support their families. Women are a majority in the project. Most of these women are old and uneducated. Though, the project is suffering from many difficulties due to the alcoholic and drug addicted male counterpart but it is at least a source of income for many of the suppressed women and children, who work as scavengers in the dumpsites.

Toxic and Hazardous Waste

Toxic and Hazardous wastes (fig 2.19) are the biggest threat to the civilians and requires special attention in terms of handling and disposal of such wastes. Urbanization and industrialization is responsible for use of more toxic and hazardous materials. Toxic wastes and hazardous wastes are not the same thing. Wastes that can cause diseases and are harmful to the human health and the ecosystems are known as toxic waste e.g. heavy metals, carcinogenic compounds, clorofluro carbons etc. Hazardous wastes are wastes that have a potential to cause harm to the life and property e.g. batteries, explosives, nuclear waste etc.

Figure 2.17 Toxic and Hazardous Wastes

It is essential to separate toxic and hazardous waste from ordinary MSW in order to avoid contamination and accidents. The handling and disposal techniques are also different. Generally, these wastes are required to be transported separately in closed vehicles and disposed of in such a fashion that avoids any impacts to the ecosystem. The waste collectors therefore are to be trained to observe all the safety measures while handling these wastes.

Unfortunately, little attention is paid to these wastes, until recently. Many of the poor countries of Asia and Africa, in fact, accept these wastes (for disposal) from the developed countries to earn foreign exchanges. In most of the cases, disposal is carried out by landfilling along with the MSW, without understanding (or neglecting) the impact of such activities. Toxic wastes like hospital wastes are often indiscriminately incinerated that have a potential of releasing toxic gases in the atmosphere. However, outlooks and awareness are changing gradually.

In several countries of Asia like Japan, Singapore, India, Thailand, use of many of the well-known toxic chemicals and gases are banned and restrictions are imposed on the production of these materials. For example, in Singapore all zinc carbon and rechargeable batteries, containing more than 0.001% mercury by weight per cell and alkaline batteries with more than 0.025% mercury by weight per cell are banned starting from 1June 1992. Imported mercuric batteries are also not allowed in order to avoid generation of hazardous and toxic wastes. The Ministry of Environment works closely with local dealers and distributors to recover nickel cadmium batteries for recycling (Waste Management in the Coastal Areas of the ASEAN Region, 1992, Chua and Garces, 1992). These efforts successfully reduce use of heavy metals like mercury, cadmium and other toxic chemicals. While, developed countries

in Asia could successfully implement such measures most of the poor countries are unable to implement these due to corruption in the system.

In some countries, steps are taken to isolate these wastes to handle and dispose them separately. One of such efforts is taken by the Calcutta Municipal Corporation, India from 1 February 1998. CMC has embarked on a project of separation of clinical and bio-medical wastes at source, for nearly 500 hospital, nursing homes, laboratories and clinics to dispose the waste in a scientific and safe manner. All bio-medical wastes for the entire city are segregated at source, transported in secured transportation vehicles and disposed of at a separate landfill. The system, which started in February 1998, has now become mandatory. The remaining establishments are likely to join in the scheme soon. This have ensured better public health and prevented unethical recycling of disposable medical items. This initiative is first of its kind in India. Calcutta Municipal Corporation has also established partnership with the private sector for waste recycling (UNCHS, 2000).

Although many of the Asian countries are already taking steps to manage their toxic and hazardous wastes, unfortunately in Africa, such efforts are yet to be observed. In most of the cities hospital wastes are discharged to the dumpsites along the municipal solid waste, with a high possibility of contamination of ground water and soil with toxic and infectious substances. Cape Town has become the dumping ground for 1.5 million liters of hazardous chemicals that have been abandoned at the Port Elizabeth recycling depot. Cape Town generates between 4,000 and 5,000 tons of waste a day, at the rate of about 1.5 kg/capita/day out of which about 10% is hazardous waste. No efforts are taken to handle this waste separately.

III. Management of Stakeholders

A. Introduction

Several stakeholders are involved with MSW management at different levels during different stages of activities. The waste generators (domestic, industry, institution), the community, local authorities, private sector, government, NGOs, educational institutions, media and a vast informal sector are all stakeholders of a MSW management system. Both awareness and participation of these stakeholders are required for the success of MSW management. In this chapter, the role of some of these stakeholders is discussed. Several case studies are presented to describe different efforts taken in Asia and Africa to promote awareness and participation of these stakeholders. Finally, the role of women in the sector has been discussed as it is considered that women can play a vital role in successful in increasing awareness and participation at the household and community levels.

B. Public Awareness and Participation

The various stakeholders in the solid waste management process can be grouped broadly as waste generators and waste processors (all agents taking part in waste processing). The waste-generating category comprises of four types of agents, namely public or households, commercial establishments (markets and hotels), institutions (offices, educational institutions and hospitals) and industries (large, medium & small).

The waste processors consist of waste pickers, IWB, middlemen, city municipal corporation and various recycling agents, both private and government and occasionally NGOs and CBOs. Waste pickers, IWB and middleman constitute the informal network while the city corporation and the recycling agents are the formal agents.

As waste generators, public (household level) awareness and participation plays a critical role in municipal solid waste management practices. Effective participation creates a sense of ownership and hence develops the interest to bear responsibility. Public participation enables the public to understand and acknowledge the constraints and challenges faced by the municipal authorities for MSW management. Unfortunately, very few citizens of Asia and Africa are aware of this fact. An interview conducted among the municipal officials in

Mumbai, India indicated that the general public awareness or participation in waste management is low. Waste management is traditionally viewed as the obligatory responsibility of the municipalities though surveys conducted in China and India showed that more than 90% of the citizens are aware of the possible health risk and environmental impacts arising from the solid waste (Martin, 1996). In most developing countries in Asia and Africa, there is a general apathy of the public towards the environmental problems as they are more concerned with economic problems.

Public awareness about MSW can be created by several agencies like the government, private sector, NGOs, educational institutes and the media. Several efforts are taken in this line in different countries in Asia and Africa. For example, to create public awareness about the resource recovery program that was launched by the government, in Metro Manila, Philippines the Department of Environment and River Rehabilitation Secretariat printed flyers containing a list of items that were collected by the eco-aides and their corresponding prices. Sketches indicating how waste can be separated in the kitchen, and information about the fate of waste paper, plastics, bottles and cans were also printed on these flyers. The neighborhood councils, NGOs and the waste collectors distributed these flyers (UNCHS, 2000).

Educational institutions can disseminate information and train the citizens by organizing seminars and workshops in their locality. Private sector can promote such workshops by sponsoring the logistics required to organize the seminars/ workshops. Media can play an equally vital role in increasing public awareness. A case study about how the media is creating awareness among the remotest part of Philippines is given in box 3.1.

Box 3.1 Awareness Created by Media, Philippines

In the Philippines, even in the remotest part of the country people are becoming aware of the need to manage waste due to the efforts taken by PEJI. PEJI is a journalist's group affiliated with the Asia-Pacific Forum of Environmental Journalists, which has been undertaking a massive environmental awareness program since 1987. The PEJI members come from news agencies, broadcast and television sector and are trained on environmental reporting. These members write about different topics on environmental awareness in Tierra, the PEJI newsletter. The articles written by the members are distributed through their own media outlets and are distributed to interested groups. Through PEJI's efforts environmental articles and advertisements in national newspapers and major radio stations find their way in weekly community papers and radio stations of small towns.

(Source: Chua, Thia-Eng and Garces, Len R., 1992, Waste Management in the Coastal areas of the ASEAN region, Association of Southeast Asian Nations/United States Coastal resources Management Project Conference Proceedings)

The strength of public and stakeholders' participation has been proved when Ahmedabad, India was declared as the second cleanest city of India in 1997. In October 1995, after the outbreak of plague in the city of Surat, India, many cities became aware of the health threats from unsanitary conditions of the city. The plague proved that an organization (municipal authorities) working in isolation couldn't be successful in crisis without the concerted effort of all the stakeholders. Mitigation efforts were initiated in 1995 in the Ahmedabad city, and were known as the 'Clean Ahmedabad Campaign'.

The initiative was a successful partnership between the Ahmedabad Municipal Corporation, the corporate sector and SEWA, a trade union of self-employed women. Ahmedabad Municipal Corporation provided a list of residential areas and initiated public awareness campaigns. The corporate sector mobilized funds for bags to collect dry recyclable garbage, and SEWA organized paper pickers known as "Arogya Bhaginis" for the collection of dry recyclable garbage. Out of an estimated 30,000 paper pickers in Ahmedabad, 6,000 were members of SEWA. In 1997, Ahmedabad was declared as the second cleanest city in India (Einsiedel, 1998).

C. Community Participation

There is a dire need for community driven initiatives in MSW management practices. This technique is almost always successful as the community has the direct sense of ownership. Cooperation of the community is essential for bringing changes in the MSW management, specially in the aspects of source segregation, recovery of recyclable materials and storage prior to collection. Active participation may also include day-to-day monitoring of collection services and maintaining cleanliness by securing uncollected waste in specified closed storage sites. There are several examples where the community has taken direct part in reduction at source, source segregation, collection of recyclable materials and participated in conducting pilot scale studies to improve the MSW management of the area. One of such pilot projects is the "Garbage for eggs", implemented in Bangkok, Thailand (box 3.2).

Box 3.2 Garbage for Eggs Project, Bangkok, Thailand

In 1997, “The Garbage for Eggs Project” was initiated by a group of 25 residents of the “70 Rai developing Community”, which is part of the Klong Toey Slum area of Bangkok, Thailand. The project started in 1997 prompted by a serious flooding in the rainy season. The flooding occurred because sewers and canals were blocked by garbage. Leaders and residents mobilized on Sundays for eight months to remove the 2,000 tons of garbage.

Aware of the fact that slum residents are used to littering, community leaders introduced the Garbage (recyclables) for Eggs project. The idea is residents exchange sorted recyclables for fresh eggs at a meeting point every Sunday from 7.00-9.00 a.m. The exchanged recyclables are sold to private junk shops. That revenue is then used to purchase a new stock of eggs. Organic and other wastes are put in the community waste bins, and are later collected by Bangkok Metropolitan Authority service crews. The few costs incurred are for purchasing egg, food for officers, transportation, and other coordination expenses. On average, 10-15 volunteers work every Sunday and serve about 100 households in each of the 23 communities.

Since the group primarily focuses on social, educational, nutritional and environmental objectives rather than economic objectives, disadvantaged and/ or neglected residents, such as the elderly, the poor, women, and children are entitled to receive more eggs in return. But the project is faced with financial and technical constraints like proper bookkeeping and accounting systems, devices that could lessen the workload of the volunteers, such as a materials recovery facility, a compressing machine, and transportation. In addition, the group has encountered difficulties with time management, coordination with new communities and marketing of an increasing amount of recyclables collected from more and more communities.

(Source: Canadian Universities Consortium Urban Environmental Management Training and Technology Transfer Program, AIT, Bangkok. Website: http://www.cuc.ait.ac.th)

These kinds of projects have been replicated in other countries also. For example, in Rawalpindi, Pakistan the United Nations Development Program (UNDP) and Rawalpindi Municipal Corporation initiated Solid Waste Management and Environment Enhancement Project (SWEEP) in the second half of 1997 in collaboration with the local communities in the city.

Rawalpindi is one of the biggest cities in Pakistan, adjacent to the capital city of Islamabad. Its population is 0.8 million with 122,000 households. The city is faced with problems of pollution and environmental degradation like any other urbanized city at times. To address these problems SWEEP was initiated. The project was aimed at developing a sustainable, participatory solid waste management system in the city. A two-pronged strategy namely human resource mobilization and development of social capital was adopted to achieve the

desired goal. Multiple objectives such as increased awareness, participation and capacity building of the community about solid waste management, increased collection and disposal capacity of Rawalpindi Municipal Corporation and collaboration among different national/international agencies and the communities have been successfully achieved (http://www.urckarachi.org/home.htm).

D. Role of Local Authorities

The participation of local authorities is fundamental to the success MSW management. A case in Metro Manila, Philippines illustrates the importance of the cooperation of the local authorities. In the early 1980, as Metro Manila Commission's identified sanitary landfills as the appropriate method of disposing waste in Manila, they selected two sites for disposal, which were outside the jurisdiction of Metro Manila's administrative boundaries. Metro Manila Commission's Environmental Sanitation Center set up a unit to manage the two sanitary landfill sites. Even before the two sites could be opened for operation, officials of the two municipalities (where the sanitary landfills were located) objected, manifesting the NIMBY sentiment. They claimed that Metro Manila Commission had no right to dispose its solid waste in other municipality areas and also their consent was not sought or they were not included in any step of the decision making process. After a very serious negotiation involving the Presidents office and protracted delay in the operation, a consensus was reached. Recent reports indicate that the inhabitants of the localities quite often disrupt the operation arguing that the sanitary landfills are a nuisance to the public due to heavy traffic, waste spillage along the roadside and due to contamination from leachate (Einsiedel, 1998).

E. Private Sector Participation

Privatization and decentralization can be positive factors for effective solid waste management projects. Currently, there is considerable interest in involving the private sector in the MSW management system in the two continents. This is motivated by the success of private sector participation in MSW management in the western and some of the eastern nations. The advantages of contracting private companies for various MSW management services are represented schematically in figure 3.1.

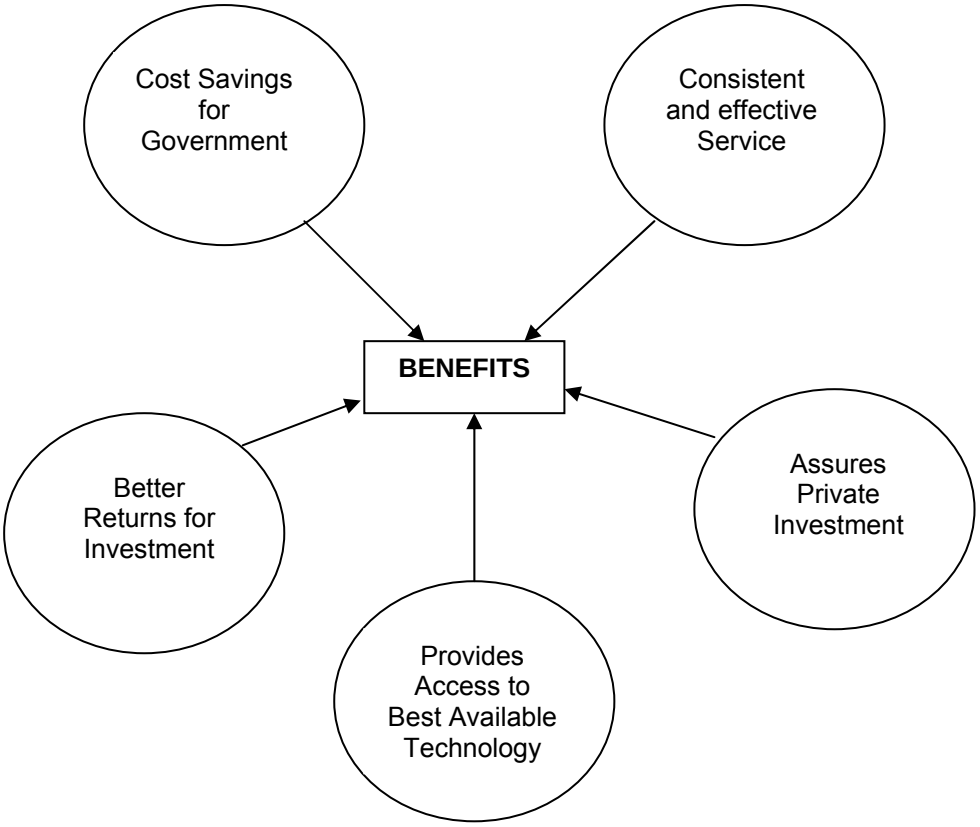

Figure 3.1 Benefits of Private sector Participation in MSW Management

Another way of involving private sector is by developing public-private partnerships. This may lead to the privatization of many aspects of MSW management, like garbage collection, recovery and disposal. Several companies such as Terra-Firma and Sunrise Industries in Bangalore, India and EXCEL Industries in Mumbai, India are collaborating with city municipalities for garbage treatment and conversion into useful manure. In some Indian cities (e.g. Bangalore), garbage collection has been subcontracted to private contractors. Due to the success of this approach, several other countries in the region like Sri Lanka, Thailand and Philippines are also adopting the practice (Mathur, 1994).

Similar strategy is also adopted in Malaysia where the solid waste management action plan divides the country into four zones, three on Peninsula Malaysia and one in East Malaysia. Each zone awards a concession to the private contractor to handle all waste collection and disposal within the zone. The private contractor is responsible for selecting the appropriate technology, conducting the required environmental impact assessments, and obtaining the required license. The city of Kuala Lumpur forms part of the central zone, which will also be eventually managed by one of the four private contractors. As of November 1998, none of the concession agreements was finalized, but until the finalization of the contracts,

management has awarded short-term contracts to the respective private companies pending finalization of the concessions (Anderson, 1988). In another case (box 3.3) in Hong Kong, landfill management has been awarded to a private company based on Build Operate and Transfer over a period of 60 years.

Box 3.3 Private sector Managed Landfill in Hong Kong

In Hong Kong, the government contracted private services under a build, operate and transfer (BOT) contract of landfills, an arrangement that involves the integration of three stages into a single procurement. The contract is made for 30 years of operation and 30 years of post closure monitoring and liabilities. The government invested in construction and equipment for the landfill, and the private contractors are responsible for construction. The municipality paid the contractor a fixed amount for each ton of waste handled at the landfill. The government monitored the incoming waste using weighbridges and measurement based on receiving area

(Source: Chua, Thia-Eng and Garces, Len R., 1992, Waste Management in the Coastal areas of the ASEAN region, Association of Southeast Asian Nations/United States Coastal resources Management Project Conference Proceedings)

While private sector participation and subcontracting services may be efficient and economic, it is certainly not a foolproof system. For instance, in the case of collection by the private sector, the waste collectors tend to serve those who directly pay and it means better services to the upper income levels and the middle class, while negligence to the low-income area and slums. Similarly, if the private sector were performing the service (collection) to make a profit from the recyclables, they would again tend to serve only those residents with “rich” waste. This would result in substantial portion of the city’s refuse left uncollected. In some occasions, the lowest bid from the private sector would also mean poor service (Johannessen and Boyer, June 1999, Chua and Garces, 1992). Strict vigilance would be required from the municipal authorities and the public to ensure that the services are properly carried out.

F. Non-Governmental Organizations

Many NGO initiatives (given in chapter 2) are being taken to tackle waste management issues. However, due to lack of funds and technical expertise, the non-governmental initiators had to be content with issuing complaints and leading protests. Some NGOs however join the government in the monitoring activities. With NGOs as part of the overall monitoring system, it is easier to move into direct community participation for monitoring,

regulation in waste management and solid waste recycling campaigns. Enterprising NGOs have started “money from garbage” projects to help provide livelihood and other supports to the needy.

The NGOs have particular strengths in reaching communities, motivating them, creating awareness about problems of waste disposal, and in ensuring their participation in a user-fee-based waste disposal program. It is also possible for an NGO to acquire new skills, such as composting and product marketing, and provide an entire chain of services, from door-to-door collection to environmentally friendly waste disposal. An initiative (box 3.4) taken by NGOs in Lucknow, India demonstrates that NGOs can play an important role in urban solid waste management.

Box 3.4 Initiative by Local NGO in MSW Management in Lucknow, India

A NGO called Muskan Jyoti Samiti (MJS) took an initiative in solid waste management to serve a population of over 100,000 in nearly 20,000 households in the Lucknow city. MJS has also started MSW management work in other cities of Kanpur, Allahabad and Varanasi, India.

MJS community mobilizes a minimum of 150 households in a locality in order to start the program. The waste is asked to be stored in plastic bags and they are in turn collected by MJS workers in handcarts. Collection fee is charged from the 3rd month of collection and they are levied depending upon the willingness and ability to pay. The cost recovery system has enabled the project to provide services such as daily collection of garbage, weekly cleaning of roads and streets, provision and maintenance of dustbins and public toilets, and transportation of waste. MJS makes revenue out of the recyclable materials as well as the compost that is made from the organic waste. MJS has its own vermi composting unit. MJS has managed to keep its costs lower than the income. On an average, 85-90 per cent of the revenue is utilized to meet the cost of operations, while 10-15 per cent is the MJS’s margin for assorted expenses and rolling capital for new equipment and expansion of its solid waste management unit.

About 10 tons of garbage is collected every day by MJS from the residential localities, wholesale vegetable, and fruit markets. Approximately 40% of the waste is inorganic (Report on Seventh Meeting Of The Urban Think Tank ‘Effective Solid Waste Management With The Participation Of Waste Producers’, Water and sanitation program, January 1999).

Lack of support from the municipal corporation is one of the major barriers in the expansion of MJS operations in the city. Such NGO-led urban MSW management initiatives could improve if there is an explicit relationship with the city Government.

(Source: Profits from Waste: An NGO-led Initiative for Solid Waste Management in Lucknow, Uttar Pradesh, India, December 1999,Water and Sanitation programme, http:// www.wsp.org)

G. Role of Informal Sector

The importance of informal sector in resource recovery and recycling and the different actors belonging to the sector is given in chapter 2. Several studies indicate that integrated approaches of MSW management involving the informal sector not only create employment for the urban poor and uneducated, but also reduce people's skeptics and inertia. Today, in most of the developing countries in Asia and Africa there exists an active informal network. This network works parallel to the formal sector and is highly labor intensive. Therefore, there is a need to recognize the existence of the informal sector and institutionalize it so that the MSW management system can function better. Figure 3.2 illustrates the various channels by which the informal sector participates in the MSW management process in the Indian cities.

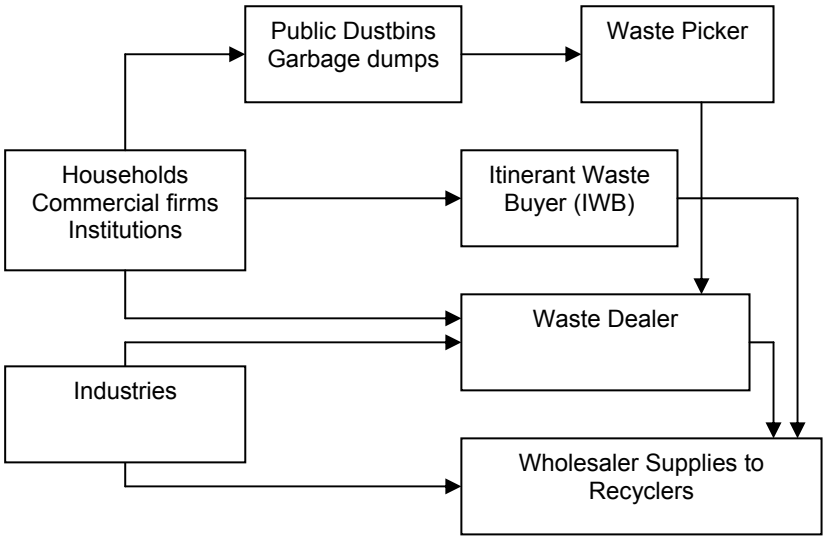

Figure 3.2 Channels of Informal sector participation in Indian Cities
(Source: Mathur, 1994)

Market forces controlling waste trading, waste recycling, and potential of earning, shapes the informal sector. The participation (number of workers) and contribution (quantity and value of waste recovered) of the informal sector varies from city to city and country to country depending mainly upon the payback from their efforts. For example in Ghana, scavenging is uncommon, as the cost of transporting recyclable materials to recycling industries in Accra and Côte d'Ivoire exceeds the value of the recyclables. However, there is no doubt that this sector makes a significant contribution to the overall waste management process. Two such cases in India are given in box 3.5.

Box 3.5 Integrating Rag Pickers in the MSW Management System, India

The Domestic Solid Waste Management Program in the low-income area of Harkesh Nagar in Delhi, India, demonstrates that decentralization of solid waste management efforts enforces upward social mobility of rag pickers. ACCORD, a national NGO, with collaboration with the local bodies, has organized rag pickers for doorstep collection service using neighborhood community and youth groups. The project, funded by the European Union, started in 1996 covers a total population of 50,000.

Through education, advocacy and motivation, the Center for Environment Education (CEE) has organized 30 NGOs in the city of Bangalore, India for the issues of solid waste segregation and storage. The 'Environmentally Sound and Productive Use of City Garbage' program was implemented in 1992 with financial assistance from NORAD and covers 20,000 households. The project emphasizes the positive relationship between rag pickers and private households. Through 'swabhimana' (self-respect) committees at the city, ward, and community levels, the program enables all stakeholders to participate in dealing with the solid waste management in the city. The municipality supports the program by providing tricycles, bags and drums and provides land in parks and gardens for composting and storage.

(Source: Report on Seventh Meeting Of The Urban Think Tank 'Effective Solid Waste Management With The Participation Of Waste Producers', Water and Sanitation Program, January 1999)

In spite of their (informal sector) positive contribution to a MSW management system, they may also pose some difficulties to the system (box 3.6). On-site scavenging is found to disrupt landfill operations in many parts of Africa. In Accra, Ghana, waste pickers sort the waste from incoming garbage trucks, before and immediately after unloading. Waste pickers often prevented the compactor from leveling and compressing the newly disposed waste. At the Krugersdorp landfill in the North West Province of South Africa, an entire village of waste pickers had sprung up close to the dumpsite. More than 600 waste pickers subsisted on income generated from sorting waste, interfering with daily operations by starting fires in order to access metals and glass. Their actions prevented landfill operators from making optimal use of compactors at the tipping face. As given in chapter 2, the Delhi (India) officials complained that the rag pickers were responsible for lowering the calorific value of the waste by removing woods, paper, plastic and other high calorific wastes, which made the incinerators inoperable.

Box 3.6 Scavengers Cause Outcry: South Africa

Durban - Every Tuesday morning, Mathombi Zuma and a group of about 20 fellow tip-pickers go scavenging for food and household discards in Boughton suburban refuse bags, leaving behind them a mess that has driven residents to appeal to the municipality to sort out the problem. Residents on Tuesday said they are forced to clean up the rubbish that the tip-pickers leave strewn over the pavement and re-bag it before the arrival of municipal waste trucks.

Tip picking “worse during school holidays”

The tip picking is more intense during school holidays, when school children can be seen undoing or ripping open refuse bags in many areas of the city. Council waste management divisional manager Ramu Raghunandan said: "The problem of people scavenging from refuse bags is very difficult to deal with because the economic desperation is far too great compared to the rubbish on the sidewalk."

(Source: Dumisani Zondi, 2001 Scavengers cause outcry, http://www.news24.co.za/News24/South_Africa/KwaZulu-Natal/0,1113,2-7-831_1075665,00.html)

Thus, uncontrolled scavenging at the landfill sites should not be allowed. Such efforts are taken at Bisasar Road landfill, Durban, South Africa. At the Bisasar Road, landfill only a controlled form of scavenging is allowed. Registered waste pickers living in slums adjacent to the landfill are allowed into the site after regular working hours. Part of the tipping face remains open for the waste pickers at the end of each working day. During regular working hours, armed guards keep waste pickers away from the landfill. Scavenging at Bisasar Road generates approximately US$15,500 to support about 200 families, equivalent to approximately US$77 per family per month.

Landfill authority allows only controlled scavenging at the Boipatong, South Africa landfill. Waste pickers at this landfill are registered and limited to 100. In another instance, at the San Mateo landfill in the Philippines, the authorities reduced some of the negative effects of scavenging by employing several people from the local slum who lived near the landfill. In the same way, limited and organized scavenging is only allowed at the Permetang Pauh landfill, Malaysia by waste pickers living adjacent to this landfill. At the Bantar Gebang landfill, Jakarta, Indonesia, approximately 640 waste pickers are officially registered by the landfill authorities. Most of them come from the nearby squatter community.

H. Participation of Women

Women have a strong involvement in improving the environment inside the house as well as outside. They are often found to be the root of many activities of awareness and motivation. This particularly relates to health and hygiene of the family members and sanitation inside, since they are the ones who are mostly affected by unhealthy condition. Currently, their potential to nurture the community environment and strength to develop awareness have been explored in many cities of Asia. However, even if women are gradually becoming more involved in the public spheres, they are facing numerous hurdles due to religious barriers, social hierarchies, traditional believes and discrimination. They are not given full recognition as an active instrument in shaping community environment. In most cases they are excluded from the decision making process.

In spite of social difficulties, there are several cases where women have actively participated in MSW management. In Cebu City, two-third of the members of the Basak Urban Poor Coordinating Council are women. This committee is composed of associations, and works in association with local authorities to clean up public spaces and collect waste. In another case, the housewives actively participate in community solid waste management and are often successful (Darmastuti, 2000).

An important reason for the sustained interest in composting activities is that composting integrates well with women's triple roles: household and family care, income generation, and community management. The location of the composting sites within market areas (in the case of Hawkers Market and Korogocho, Indonesia) where the women engage as sellers allow them to monitor their businesses while undertaking composting activities. However, in some cases, location of composting site can make their daily responsibilities more difficult. In the case of Kinyago, Indonesia, the composting site is located across a busy road making it difficult for the women to monitor their children and to haul water across the busy road for the composting site. Thus, it is important that the composting plots be strategically located to ease the burden on women in case community composting is encouraged.

In another case, in Nairobi the NGOs recognized the role of women as community managers by initiating composting projects that targeted pre-existing women's groups concerned with community health care and income generation. Composting proved complementary to these activities by providing a healthier living environment and diversifying their sources of income. Like other women group activities, composting also

provides a forum for women to exchange information and ideas, which exceeds the importance of generating income for majority of the Nairobi composting groups.

Some groups also use the profits gained through composting to improve much-needed community facilities. The Kuku women in Dandora, Kenya invested some of their composting profits in a nursery school for their children. This eases their childcare responsibilities, enabling them to engage in other important activities. The Kuku women have also used the money to purchase utensils and dishes for entertaining guests. They enjoy the prestige and publicity that their composting efforts bring them. This also reinforces a sense of pride in their community, which they enjoy sharing with visitors. Many of these visitors are brought to meet the Kuku women by the NGOs in order that they too become enthusiastic about starting a composting project in their own community.

Unfortunately, such activities are not entirely free from gender-related constraints. All of the groups lack significant support from men in the community. The composting activities are almost entirely carried out by women, though some women do receive occasional help from husbands or sons. At the same time, the women's groups depend on a male chairman to represent their interests to the rest of the community. This may not be the best possible arrangement for addressing women's strategic needs, including political empowerment and the recognition of the importance of their work. One of such cases is given in chapter 2, for Dandora waste dumpsite, Nairobi. It was mentioned that the uneducated, poor, old women working for the dumpsite are facing many difficulties. This is due to the oppression by their male counterpart, who takes advantages of the situation. Though these women are the majority in the Mukuru Recycling Center there is no representative of them and the control of the worker community remains in the hands of male workers who are mostly alcoholic and drug addict. Several factors like uneducation, old age, lack of confidence, lack of communication are the major deterrents of the women workers.

IV. Management and Instutional Aspects of Municipal Solid Waste

A. Introduction

Many planning efforts in developing countries have emphasized technology at the expense of management support systems. An acceptable level of service for waste management depends critically on well-planned management, operating within an adequate institutional arrangement, which is capable of generating the financial resources required to meet operating, maintenance and investment costs. This chapter discusses with some of these essential infrastructural elements required for the success of a MSW management system. At the end of the chapter, some of the main challenges facing the management of MSW in the cities of Asia and Africa have been discussed.

B. Organizational Structure

Even though solid waste service is one of the largest employers of labor in most developing countries, it is relatively uncommon to find a single department having direct responsibility for all aspects of solid waste management. Most of the municipal authorities in these two continents lack definitive organizational structure that can promote integrated solid waste management system. Usually, different departments within the municipal corporation are responsible for different activities pertaining to MSW management, which increase complications in planning, implementing, financing, coordinating and operating the system. The net effect is poor services, more public grievances, unplanned use of budget and sometimes failure of schemes. A typical bureaucratic structure of the MSW management system in China is shown in fig 4.1.

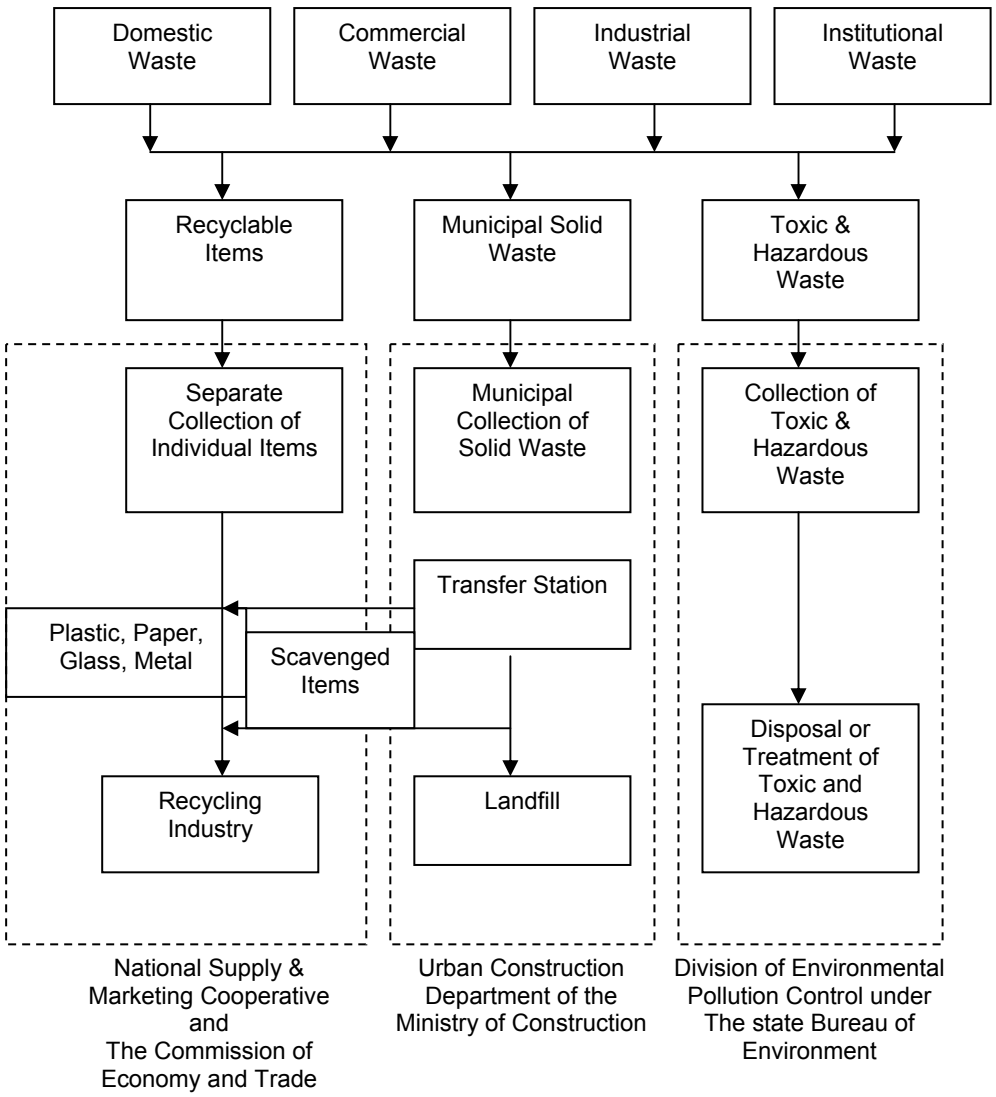

Figure 4.1 Organizational Structure of Waste Management in China

It can be seen from the figure that several authorities are dealing with different waste fractions, making the whole structure much more complex. Collection and treatment of municipal waste belongs to the Urban Construction Department of the Ministry of Construction at the national level. The National supply and Marketing Co-operative Association and the Commission of Economy and Trade are responsible for segregated waste collection and resource recovery. Moreover, the Division of Environmental Pollution Control under the State Bureau of Environmental Protection is responsible for the hazardous waste. The same type of structure is also noted in Darussalam, Brunei as given in box 4.1. Overlapping of responsibility as well as lack of clear and specific roles among different functional units are the main reasons for such inefficient MSW management.

Box 4.1 Solid Waste Management Systems in Brunei Darussalam

In Brunei Darussalam, no single agency has the responsibility for solid waste management. Although the Medical and Health department monitors public health, and has no administrative role in solid waste management (SWM), it advises the municipal bodies and the district offices. The municipal bodies and the district offices are responsible for the day-to-day collection of the waste. While the Public Works Department (PWD) conducts studies, implements projects and sets up SWM facilities such as disposal sites, communal bin system and cleanliness along major roads. A study (1992) conducted on the MSW management of the city recommended that a single authority with full operational responsibility be established

(Source: Chua, Thia-Eng and Garces, Len R., 1992, Waste Management in the Coastal areas of the ASEAN region, Association of Southeast Asian Nations/United States Coastal resources Management Project Conference Proceedings).

Such studies show that division of responsibilities among various authorities and decentralization of responsibilities instead of simplifying the problem increases the complexities specially at the governmental level. Contrarily, clearly defined organizational structure with definitive roles and responsibility are more successful as is given (box 4.2) for Khulna, Bangladesh.

Box 4.2 Organization of Pilot Solid Waste Management Project in Khulna, Bangladesh

The pilot project for community based solid waste management in Khulna city was launched in March 1997 with a scheduled completion date of December 2000. The project operated in 6 of the 31 city wards; these were chosen to represent a cross-section of the city areas (built up, peri-urban, slums, etc.). Roles of the different project partners were clearly defined at the beginning of the project as is listed in the table.

Communities (in the project areas)	Management of the Primary collection system and contribution towards its' cost
Khulna City Corporation (KCC)	Collaboration, institutional support and onward links to municipal systems.
Prodipan (NGO)	Lead agency to implement the project activities
Swiss Agency for development and Cooperation (SDC)	Management and project funding
Water and Sanitation Program (WSP)	Strategic supervision and technical support.

(Source: Community Based Pilot Project on Solid Waste Management in Khulna City, Bangladesh Water and Sanitation program, http://www.wsp.org)

C. Decentralization

The old bureaucratic system, which is being practiced in many Asian and African countries, is saddled with a highly centralized system of decision-making, command and resource allocation. Thus, decisions that affect the lives of the residents living thousand of kilometers away are made by bureaucrats who are not necessarily familiar with the local conditions. Decentralization is one of the steps towards achieving sustainable development. It helps to plan and implement such waste management systems that consider the local conditions, culture and sentiment, involve local community and generate local awareness and employment, all of which are key success factors of such systems.

Philippines took such an effort to decentralize the Department of Environment and Natural Resources in late 1980s to make it more accessible to the public. About 85% of its funds were reallocated from the central office to the regional offices. Most of its management and

technical staff were deployed in the field. Provincial and community offices were established to extend the services of the department. Regional offices assumed many of the developmental and regulatory functions used to be performed by the central office (Chua and Garces, 1992). The effort successfully created a better organizational structure.

D. Resources and Skill

Deficiency of resource (like information, equipment, technology, human resource) and skill (technical and managerial) is one of the fundamental drawbacks of many municipal authorities responsible to oversee MSW management. Development of skills and deployment of resources is mainly hindered by the lack of finance. In many cases, the authorities are unaware of the technological developments, new researches and projects undertaken in other countries. Lack of information exchange mechanism even within a country slows development and increases cost.

Lack of equipment and manpower is another major hurdle for development. Inadequate financial support from the government and other sectors, lack of proper tax structure and inability of the system to generate its own finance are the main causes of such shortages. Though, cheap manpower is available in almost all the developing countries in Asia and Africa, they are largely unskilled. Skilled workmen are unavailable due to lack of training and often poor salary structure. Technical people often have a strange apathy to serve for such sector, which is traditionally not accepted as a dignified service. This is coupled with lack of managers experienced in the trade. In most cases, the governmental officials are transferred amongst different government departments handling different trades and proper experience and expertise are never developed. Other bureaucratic factors also discourage proper skill development.

These officials often lack management and administrative capabilities of handling public services, planning, forecasting, project financing and contract management. In many countries political interests and corruption also hinders proper functionality and destroys working environment that discourages many professionals to work for the government. In one of such cases, the inadequacies of the responsible officials about contract management was revealed when three major refuse collection contracts in Bangkok, Thailand were found to lack specifications of the services, penalties, bills of quantity and specification of supervision (Chua and Garces, 1992). These deficiencies in the contract allowed the

contractors to take the advantage of the situation and the service was poor giving rise to a number of public grievances.

E. Efficiency

Efficiency of the MSW management system is affected by shortage of equipment, staff and other infrastructural facilities. Bureaucratic procedures, political interference, work culture, corruption, lack of incentives and lack of respect to the organizational rules reduce the overall efficiency of solid waste management. In many municipal authorities, there is a high job security. Except in case of fraud, embezzlement or criminal acts, government servants seldom loose job. There is no procedure to inquire about the efficiency of a staff and the promotion is not based on efficiency but on years of service. Thus, there are no means to improve efficiencies of the staff of the municipal authorities, who most often are engaged in obtaining personal gains using the weaknesses of the system.

Lack of adequate supervision and maintenance staff is another reason of low efficiency. Industrialized countries usually have one supervisor for every 5 – 7 collection vehicles, whereas in many developing countries one supervisor looks after 10 - 30 vehicles, which results in frequent breakdown of vehicles and disruption of services. Often these supervisors don't have any means of moving within their service area for monitoring and the average collection time far exceeds the estimated figures. It is found that while the average downtime for vehicles might be around 10% for an industrialized country, typical figures in the Asia and Africa vary from 20% to 50 %. Maintenance of the vehicles and earth moving equipment is often reactive (repairing after it has broken down) rather than preventive, resulting in long breakdown time and reduction in effective life. This is often due to inadequate funds, shortage or unavailability of spare parts, lack of trained technician and general negligence.

F. Monitoring

Monitoring of solid waste handling, collection, transport and disposal services is often overlook by the authorities. This is mainly due to lack of adequate finance for purchasing efficient monitoring system, understaffing, lack of public relation and negligence to duty. Nowadays many modern technologies are available that enables efficient monitoring. For example, Singapore has a computerized "waste management system" which provides on-line monitoring of performance status of each refuse collection vehicle (Chua and Garces,

1992). However, such sophisticated technologies require both finance and skill to implement, operate and maintain, which is lacking in most of the developing countries in Asia and Africa.

Monitoring and supervision of landfill operation post closure monitoring of the impacts on the environment and public health is another aspect, which has been ignored in the past. There is a need to develop simple and affordable programs to monitor the environmental effects of waste disposal and to provide local authorities with the necessary guidance and supervision to implement technically appropriate and environmentally sustainable approaches for landfill operation. The success in managing wastes also depends a great deal on the policies and institutional support directed towards small-scale industries that tend to be no less polluting than the large scale industrial units. The small-scale industries are much difficult to monitor and regulate (Chua and Garces, 1992), as these are scattered over a wide area and these don't have any records of waste generation.

G. Legislation

In many countries in Asia, national legislation regulating waste management exists. However, in many of these countries enforcement of these regulations are poor or delayed and usually there are no local level legislations on solid waste management. For example, the Minor Offences Act, Chapter 30 of the Laws of Brunei Darussalam is a comprehensive legislation for litter and indiscriminate dumping. The violation of the act carries a penalty of Brunei $1,000 (US$ 1 = Brunei $ 1.85) for the first offense and B$3,000 thereafter. It includes a section on abandoned vehicles in public lands. However, its enactment was delayed until a nationwide cleanliness education campaign was completed (Chua and Garces, 1992). Even though there was a national legislation, the legislation was weak as no specific authority was responsible to enforce the act. In several cases, due to lack of local legislations, municipalities are unable to solve conflict situations especially the inter-jurisdictional conflicts. This results in a standstill or protracted delay in the negotiation and hence delays in implementation of projects.

Currently however in many Asian countries, national action plans and local legislations are initiated in order to address problems related to waste disposal. For example in China, a very comprehensive set of policies governing MSW management has been developed. Ministry of Construction and the Department of Urban Construction are jointly responsible for solid waste disposal in China. The agency has developed guidelines and requirements for management of solid waste disposal, including landfills (regarded as the primary disposal

option), composting, and incineration. In its guidelines, China addressed siting criteria (such as minimum distance to drinking water sources, limitations on geological formations and requirements for hydro geological surveys), liner criteria (such as clay liner thickness of 2-2.5 m and permeability < 7 -10 m/sec), and a series of guidelines on disposal techniques and management procedures. The licensing procedure involves a mandatory Environmental Impact Assessment (EIA) process and approval from the local Environmental Protection Bureau, advised by a competent technical institute (a so-called Class A institute). The EIA process involves public consultation and a possible compensation package to the affected parties (Johannessen and Boyer, June 1999).

In another situation (box 4.3), the Supreme Court of India constituted a committee to look into solid waste management practices and identify deficiencies in the existing system. Similarly, the South African Government banned thin plastic bags (box 4.4), known as vest-type carrier bags that are commonly used for carrying grocery. These bags are so thin that it is not economically viable to recycle the bags. Therefore, the government banned the use of vest-type carrier bags in order to avoid difficulties associated with disposal of such bags. Though such efforts are definitely a positive move towards a more integrated MSW management however, strategies and plan are also required for proper implementations of the rules. The presence of corruption and various difficulties related to inspection and supervision of proper implementation is required to be handled parallely to development of legislations.

Box 4.3 The Supreme Court's support for Solid Waste Management, India

In 1996, the Supreme Court of India entertained Writ Petition No. 888 and constituted a Committee to look into solid waste management practices and identify deficiencies in the existing system. The Committee is comprised of practitioners in the field and representatives of relevant ministries. The report has made specific recommendations on steps to be taken by urban local bodies to improve SWM in their cities. The report deals with three categories of issues:

1.Actions to be undertaken by urban local bodies in a given time frame;

2.Technological options available to the local bodies for storage, primary collection, transport, processing and disposal of waste, supervisory levels, work norms, the type and number of vehicles to be used, allocation of funds to be made, and health and legal aspects of SWM; and

3.Interventions that the State and Central governments may consider to support the urban local bodies in their endeavor to improve SWM practices in their cities

(Source: Report on Seventh Meeting Of The Urban Think Tank 'Effective Solid Waste Management With The Participation Of Waste Producers', Water and sanitation program, January 1999)

Box: 4.4 Banning of Thin Plastic Bags by the South African Government

Thin plastic bags, known as vest-type carrier bags (VCBs), that are use for grocery, are so thin (17μm on an average) that it is not economically viable to recycle them. So they are discarded. In an effort to prevent this, and develop a more environmentally sustainable way of carrying groceries, several approaches have been taken:

1. There is a global trend towards legislation specifying an increase in the minimum weight/thickness of plastic bags, in both the developed world (e.g. the European Union) and the developing world (e.g. India).
2. Littering has also been approached from the point of view of fines for littering; for example Singapore has dealt very effectively with its litter problem by introducing harsh on-the-spot fines.
3. Biodegradable plastic is widely used as an alternative. Starch and other additives are introduced into the plastic, which can then be broken down in a variety of ways, including photochemical and oxidative processes.

(Source: Southern Africa Environment Page, http://www.saep.org/forDB/forDBFeb01/PROVECWastefromPECT010227.htm)

H. Economics of MSW Management

Solid waste management is one of the largest employers of labor and transport. In many cases, it consumes the largest proportion of the municipal budget of the city. Providing adequate funds continuously is a major hindrance in many developing countries of Asia and Africa specially for small and medium cities, where revenue generated from such services is very low. Traditionally, this service is supported from the general municipal revenue, due to lack of any separate tax structure for solid waste management services in many countries. For example, in Hong Kong, the government is responsible for financing solid waste services. Neither residents nor industries are charged for such services. Landfills do not charge tipping fees regardless of waste origin. Landfill operation cost is estimated to be approximately US$10 per ton of waste, excluding the costs associated with leachate treatment. As a result, it is a key area of concern of the municipalities. Efforts to improve this sector are found to improve the overall municipal administration system.

Usually the cost of solid waste management is about 20-40 % of the total municipal budget. Out of which, 70 to 80 % is consumed for collection and transportation of solid waste, and the rest is allotted to the disposal of waste (Chua and Garces, 1992). The per capita expenditures for solid waste management services for different Asian countries are shown in fig 4.2. It is evident that industrialized and developed countries are investing more compared to the middle-income countries due to better services.

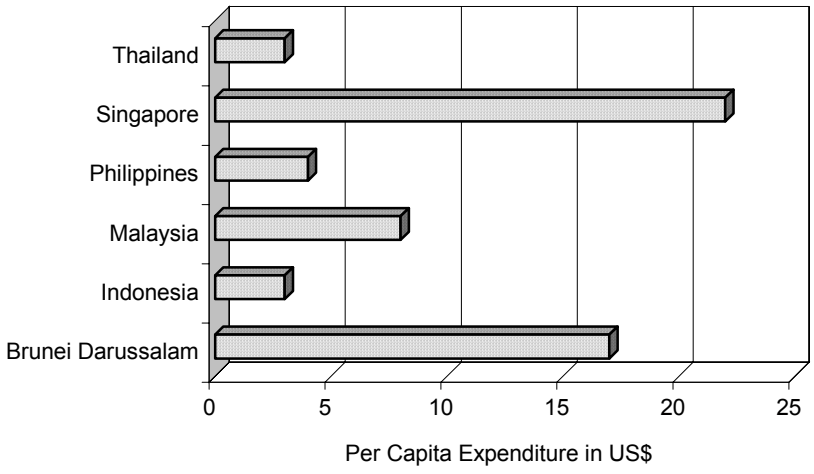

Figure 4.2 Per Capita Cost of MSW Services
(Source: Chua and Garces, 1992)

Table 4.1 shows the tipping fees of MSW for different countries of Asia in comparison to the GNP. (Discussion required. Please explain why figures are so erratic). A cost breakup for different activities of MSW management is shown in box 4.5 for Northeast Beijing, China. The average charge of waste disposal in the region is about US$10 per ton. The price does not reflect the landfill size or type of contractual agreement (what does that mean?).

Table 4.1 Tipping Fees for Different Countries in Asia in Comparison to GNP
(Source: Chua and Garces, 1992)

Country	Tipping Fees US $ / ton (approx. Range)	1996 GNP Per Capita (US$)
Malaysia	1.2	4,300
Philippines	9.7	1,190
Indonesia	1.3	1,190
China	2.5	750
Hong Kong	10.0	22,010

Box 4.5 Cost Breakup for MSW Management, Northeast Beijing, China

Collection	US$3.6/tonne
Transfer	US$3.6-4.2/tonne
Disposal	US$2.4-3.6/tonne
Total costs	US$9.6-11.4/tonne

(Source: Johannessen, Lars Mikkel and Boyer, Gabriela, 1999,"Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America". Urban and Local Government Working Paper Series #3, World Bank, Washington, DC, 1999a)

Programs that would be benefiting the public in the end are often impossible to initiate because of lack of finances in several countries in Asia and Africa. Figure 4.3 shows the percentage of GDP that each country has to spend on waste management. It is seen that while industrialized and developed countries e.g. Singapore has to spend only 0.67% of the GDP on waste management, countries like Indonesia have to spend 6% of their GDP for the same. Therefore, at times adequate financing of such services becomes unaffordable. The answer to this dilemma is to seek low cost, alternative waste management programs. Given the high rate of economic growth, industrialization and urbanization in the region, a further delay of effective waste management programs will require more expensive solutions as the

problems intensify. Therefore, the emphasis is to create affordable programs as early as possible (Chua and Garces, 1992).

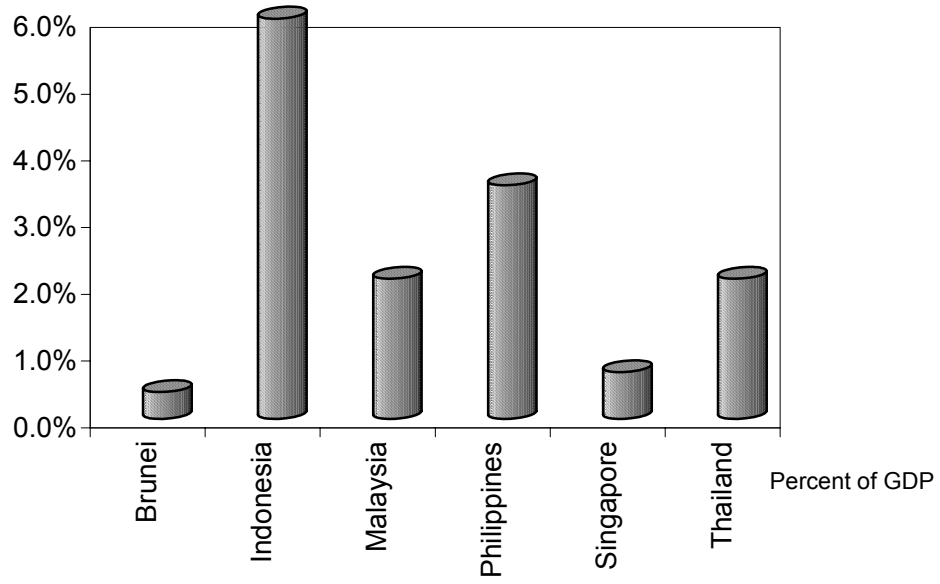

Figure 4.3 Percentage of GDP required for Solid Waste Management

I. Financial Measures

Financial measures can be exercised to reduce the quantity of solid waste generated. These are found to be one of the best ways to quickly impart civic sense to the citizens and reduce uncontrolled waste disposal by industries and institutions. Adoption of such measures also enables the local authorities to control indiscriminate dumping and littering of city roads, commercial and institutional buildings, parks and public places. Such an example for Brunei Darussalam (Minor Offences Act, Chapter 30) is given earlier, which reduced the littering to a substantial degree.

In another instance, Calcutta (India) High Court maintains a ‘Green Bench’ to deal with the environmental issues. The existing legal system prohibits throwing of waste on the road by levying fines. The Municipal Corporation has implemented the directive by introducing a garbage carrying and removal charge of Indian Rupees 20 (US$ 1 = Indian Rupees 47) per occasion of littering in the domestic areas and Indian Rupees 50 (minimum) in commercial areas to any person dropping garbage on the street (Water and Sanitation Program, January 1999).

Imposition of charges and service fees for waste management is a very effective financial instrument to reduce the volume of waste generated. The case study from Inchon, South Korea (box 4.6) demonstrates that imposing volume-based collection fee has been successful in Inchon. The overall objective of the program is to make the city greener, and cleaner.

Box 4.6 Volume based collection fee in Inchon, Korea

In 1995, the Metropolitan Government launched the Green Inchon 21 program. One component of the program was the introduction of a volume-based collection fee system. The residents of Inchon responded positively to the volume-based collection fee system. The total quantity of waste produced in Inchon before the start of the program was 2,272 tons per day. After the program had been launched, the quantity of solid waste generated was 1,598 tons per day, a reduction of 30 per cent. At the same time, the collection of re-usable waste increased from 184 tons per day to 264 tons per day, an increase of 43.4 per cent. These figures do not include the collection of re-usables by private-sector dealers. The actual amount of re-usable waste, which is recovered, must be much more. The use of standardized plastic bags for solid waste reached a level of 99 per cent at the end of July 1995.

The revenue generated from the collection fee increased from Won 3,179 million (US$ 4 million) for the first half of 1994 to Won 9,349 million (or US$ 11.6 million) during the first part of 1995, an increase of 195 per cent. At the same time, the authorities reduced the collection fee for households in the low-income groups. The increased revenue made it possible for the Waste Control Division to become self-supporting and to construct in waste pretreatment facilities.

(Source: UNCHS, 2000, The volume-based collection fee system: A means for effective waste reduction in Inchon, Korea, Best practices database, http://www.bestpractices.org)

In the Philippines, each municipality charges a basic tax for every load of incoming waste. However, there are variations in the charging rate within the country itself. The municipality of San Mateo collects US$1 per 4-wheeled truck (10 cum) and US$1.5 per 6-wheeled truck (15 cum), while the municipality of Carmona landfill charges US$5 per incoming truck. Taxes charged by the municipalities are not included in the landfill's operational budget. The estimated landfill cost for the two Metro Manila landfills is approximately US$10 per ton of disposed waste.

However direct user charges for such services have some disadvantages also. Three particular problems with direct charges are:

1. There is usually no viable means of shutting service to a resident with unpaid bills
2. Direct charge encourages indiscriminate dumping and

3. Those who can afford to pay for such services live in better-income areas where good services are provided.

Therefore, in many cities of Asia, direct user charges for refuse services are relatively uncommon, and wherever such taxes exist, collection rates are often very low. For these cities, acquisition of necessary funding is one of the major constraints. Most developing Asian cities lack sufficient financial resources to build, operate and maintain solid waste management facilities. However, there are other alternatives for funding and operating such as privatization of the facility as in the case of Malaysia or through built-operate-transfer (BOT) programs as done in Hong Kong (box 4.7), where the government is released from direct funding.

Box 4.7 BOT Programs in Managing Landfills

In Hong Kong, a landfill in the South East New Territories, which opened in February 1995 as part of a network of such facilities, was designed, built and operated by the Green Valley Landfill, a joint venture of Waste Management International, Citic Pacific and Sun Hung Kai Properties. Funding for the project was arranged by the joint venture.

In Malaysia, Kualiti Alam, a private company that won the bid in 1996 to build, operate and maintain the facility, implemented its first central toxic waste treatment plant in central Negeri Sembilan State. (Johannessen, Lars Mikkel and Boyer, Gabriela, June 1999, Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America Urban Development Division Waste Management Anchor Team, World Bank)

(Source: Far Eastern Economic Review, Feb 23,1995 and November 17,1997)

J. Challenges

MSW management poses several challenges to the stakeholders and specially the decision makers. The challenges can vary depending on the nature, culture, education level, income level and commitment of the stakeholders. In most of the Asian and African countries, these can be broadly classified into technical challenges, financial challenges, institutional challenges and social challenges (increase public awareness, and promote source separation, recycling, participation, gender equality, change of traditional beliefs).

Due to scarcity of land in many cities and suburbs in Asia and due to the typical NIMBY sentiment, innovations are required in solid waste management practices specially for siting of landfills and improvement of disposal practices. Providing a solid waste management facility that is desirable and acceptable to the public is an enormous technical and

management challenge for the decision makers and the municipal authorities. Social acceptability would mean acceptance in terms of location of the disposal site, impacts on public health and sanitation, collection services and cost to the public (taxes, charges).

The rate of change in MSW quantities and composition of Asia is unprecedented. As the lifestyle rapidly changes, the related conveniences and products like mobile phones, electronics, plastic items, disposable diapers and a huge list of items continue to pose special waste disposal challenges. Many of these items generate hazardous and toxic wastes, which requires special care in handling and disposal. Many of the countries in Asia and Africa lack the technical capability to handle these wastes. The waste management practices woefully lag behind the realities of a quickly changing character of waste stream (Martin, 1996). Therefore, the authorities have to work within a constrained technical and management framework.

Advanced technologies, which are imported, requires additional consideration of suitability and applicability due to changing nature of the waste and climate. Several cases of failures in these cases have been reported due to failure to consider the waste characteristics, climate, availability of operational skill and finance in the local context. Further, the impacts of these technologies also need to be evaluated in local context. Thus, importing advanced technology is not a panacea and poses other technical challenges. Implementation of best practices would thus require a balance between several local factors like geographic area, climate, nature and quantity of waste generation and the social factors. Added to these would be lack of equipment, infrastructure, skill and financing. One way to tackle these aspects would be to search for a locally developed low cost, effective technologies and practices.

Financial challenges are ubiquitous in most of the countries in Asia and Africa. Lack of capital and operating finance and inadequacy of the MSW management systems to generate its own cost is probably the root of all the problems. It poses the greatest challenge to any MSW management. Several attempts are made to solve the problem some of which are successful while others are not. Financial problems will therefore likely to continue to pose challenges in years to come and may even aggravate for some cities.

In many developing countries of these two continents, there is a conflict between economic development and environmental protection. The strict requirements of the environmental protection agency sometimes turn investors off. On the other hand, the promoters of business and industries believe that they are boosting the economy; notwithstanding the

serious environmental consequences, they are creating by disposing wastes uncontrollably. Balancing these two interests, which are apparently contradictory, requires not only technical expertise, but also a restructuring of socio-economic structures, values and attitudes (Chua and Garces, 1992).

Generally, there is a negative view towards the waste-pickers or the “scavengers” in Asia due to the nature of their work. They are treated meanly and are not considered as a part of the society. Decision makers seldom consider the right of these people in the community, in spite of the fact that their participation in this sector is mutually beneficial. In some cases, in order to modernize the waste collection and landfill operations the poor rag pickers are evacuated from their settlements and their source of livelihood is affected. Their contribution to the recycling industry and waste reduction is not taken into consideration. Many institutional challenges lie ahead pertaining to acknowledgement of the contribution of the informal sector towards the MSW management and integration of the informal sector and other stakeholders like public, private contractors, into the main stream (Einsiedel, 1998).

Traditionally in developing countries, inhabitants as well as political decision makers are not fully aware of the risks from open dumpsites and leachate from the landfills. Since the landfills are away from the city’s residential area the likely impact of open landfilling or uncontrolled disposal are neglected. Only a crisis can force people and authorities to take appropriate action and adopt better practices. The typical case of Surat, India (chapter 2), is one such example. The attitude of the inhabitants and the authorities changed only after they faced the crisis. Such tendency may do much harm to the public health before they could be corrected.

The challenge is therefore to generate more awareness among the public and increase their participation. With regard to technicalities of solid waste management, effective public information and creation of awareness would meet two major challenges:

1. Reduction in the quantity of waste generation and increase in recovery and recycling, and
2. Development of a sense of responsibility amongst citizens and stakeholders about their role in the system.

Public awareness is also likely to put pressure on the decision makers to view problems related to solid waste management more seriously and to take action on it.

V. Recommendations: Integrated Solid Waste Management (ISWM)

A. Introduction

Various concepts have been developed over the years to provide the basis for improving the management of solid waste in developing cities. Among these, the concept of Integrated Solid Waste Management (ISWM) provides a framework of developing a sustainable MSW management system, which has been very successful in various industrialized countries. In this chapter the concept of ISWM, requirements of ISWM and the concept of waste hierarchy are explained. Finally, general recommendations for developing an ISWM in Asia and Africa have been given.

B. Integrated Solid Waste Management

The ISWM model aims to evaluate alternatives for the efficient management of urban solid waste by including all stakeholders. ISWM is a very broad concept covering almost all the aspects of MSW management. Figure 5.1 shows the general framework of ISWM and figure 5.2 shows the externalities of an ISWM. Essentially, ISWM requires that decisions on waste management should take into account at least the following aspects:

1. Economic
2. Environmental
3. Social and
4. Institutional

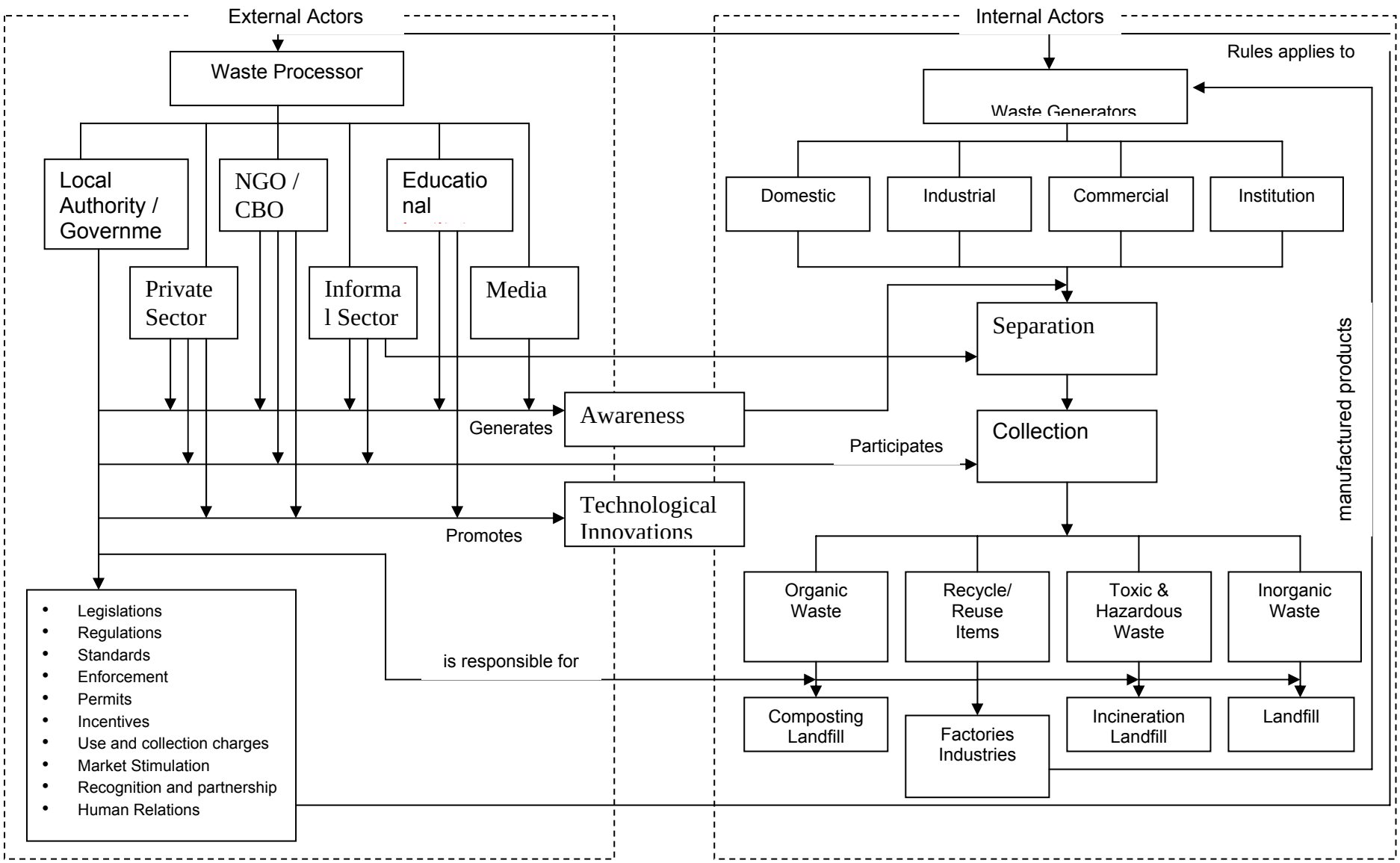

Figure 5.1 Conceptual Framework of Integrated Solid Waste Management

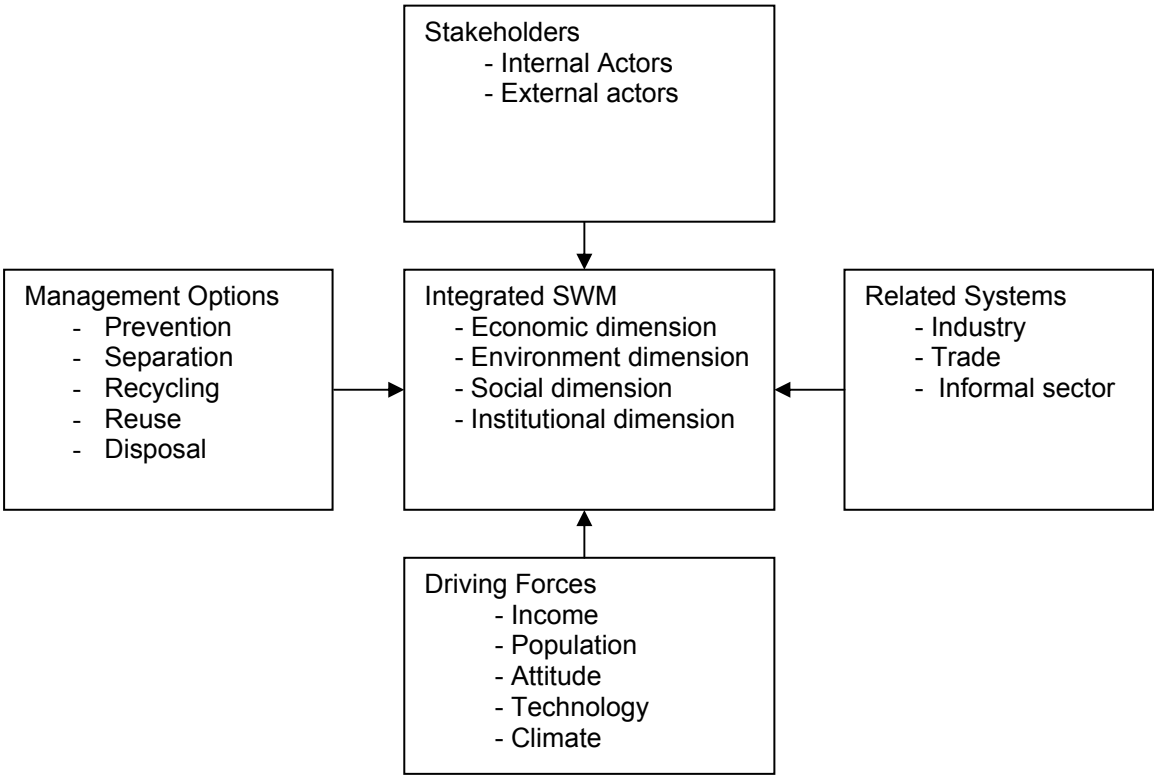

Figure 5.2 Externalities of an Integrated Solid Waste Management
(Source: UNCHS, 2000)

Economic Aspects

The costs and benefits of implementation, available municipal budgets for waste management, impacts from taxes or service charges, earnings from recycling of waste, self sustainability of MSW systems and the spin-off effects for other sectors in the economy in terms of investments are some of the factors that require to be considered under this group.

Environmental Aspects

This group considers environmental impacts that may consist of local problems (i.e., increased risk of epidemics and groundwater pollution), regional problems (i.e., resource depletion and acid rain), and global problems (i.e. global warming and ozone depletion).

Social Aspects

This group includes various social effects like generation of employment, opportunities for both the formal and the informal sectors, impacts on public health, public and community awareness, change of traditional beliefs, socialization of scavengers and other ethical issues such as child labor.

Institutional Aspects

Consideration of institutionalizing informal sector, development of organizational structure with clearly defined role and responsibility, involvement of various stakeholders and women, privatization of services, development of legislative structure and ordinances, enforcement of regulations are some of the important institutional aspects.

C. Basic Requirements of ISWM

An ISWM should at least be (CREED, 2000):

1. Responsive: balancing the local needs with wider institutional, technical and environmental constraints

2. Equitable: addressing the needs of all sectors of the community

3. Empowering: motivating and organizing local people to help them find solutions to problems at the local level by using indigenous ideas

4. Decentralized: into local authorities responsible for all problems of MSW over the whole city

5. Diverse: experimenting with a range of technologies or processes rather than attempting to find one single solution applicable to all situations; and

6. Flexible: to allow developments and modifications in approaches and activities.

In practice, it is difficult to balance all these aspects at the same time, since the factors affecting MSW management are constantly changing. These problems are more severe in developing countries, where limited resources, budgets and infrastructure, force several

comprises in developing a system. As a result, policies tend to focus mainly on the waste hierarchy.

D. Waste Hierarchy

The waste hierarchy (fig 5.3) is an accepted key element of ISWM. Environmental principles, is the basis of this hierarchy. It proposes that waste should be managed by different methods according to its characteristics. The preference of the options represents the hierarchal structure. Thus, prevention, reuse and recycling are given the highest preference, while open burning is unacceptable. The hierarchy is designed to improve the environmental aspects of ISWM. Practices, which produce serious impacts on the environment, form the lowest level of acceptance.

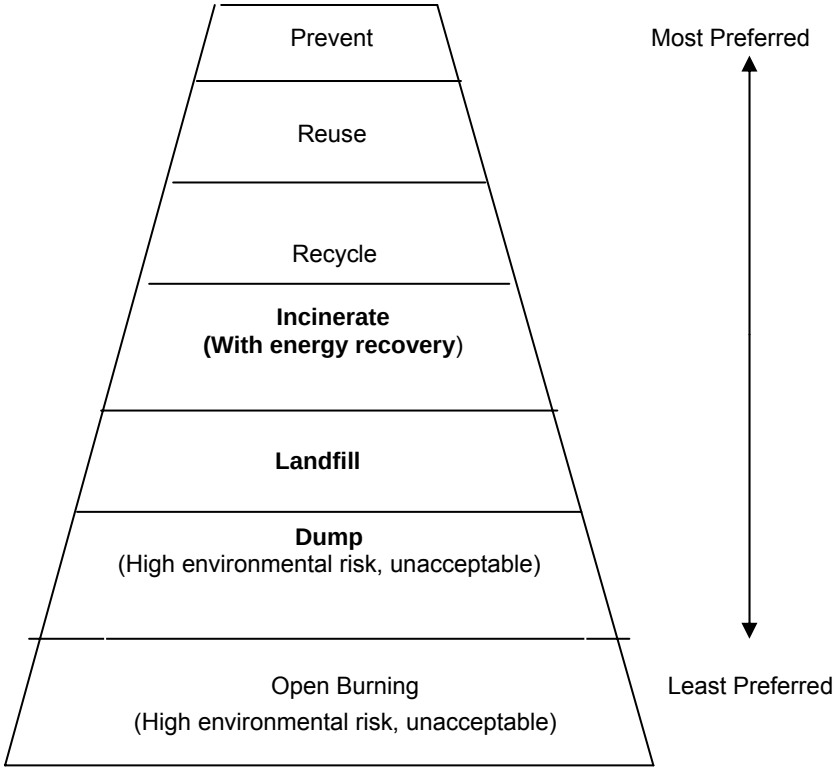

Figure 5.3 Waste Hierarchies

Though the waste hierarchy provides an effective basis of solid waste management, it acts only as a guideline in practice. Although the ranking may indeed be correct in terms of environmental aspects other factors like economy, social or institutional may not support the hierarchy in every cases. While prevention may be best from every aspect, recycling may not be economically viable in particular situation and thus it tends to deviate from the general hierarchy for that situation. Similarly, incineration may not be socially acceptable due to NIMBY sentiments. It may be better to recycle an old refrigerator rather than reuse it

because it may consume more energy in its old state creating more environmental damages than being used as a raw material in the primary industry. Therefore, the hierarchy should be used flexibly.

E. General Recommendations for ISWM development

Along with the traditional practices, researches have to be initiated by the governmental and the non-governmental agencies. Location-specific options in response to the needs of the local problems should be considered parallel to the options of importing technologies. The practices should encompass the following aspects along with the basic requirements of an ISWM:

1. Public participation in the collection, segregation and disposal of garbage by forming eco-clubs or community based organizations.

2. Involvement of NGOs to work for various community based solid waste management programs that may improve social awareness, emphasize participation, create job opportunity for the needy, encourage small scale technology like composting and remove gender inequality.

3. Public-private partnerships leading to the privatization of some aspects of garbage collection, recovery and disposal. Relationships can be formalized by establishing Memorandum of Understanding, legal agreements between NGOs and user groups, and by ensuring enforcement of such agreements. Even informal linkages should clearly define roles and responsibilities of all stakeholders.

4. Initiate provisions aimed at administrative restructuring of the local municipalities to enable them discharge their responsibilities more efficiently. Improvement can be brought about by i) motivating the municipal staff and improving their capacity by training and by improving methods ii) monitoring and supervision of waste management practices by the officers and iii) introducing structural changes within the administration aimed at decentralizing authority and responsibilities.

References

1. Aborjona O Paribesh, 1999, A newsletter on waste management and Recycling in Bangladesh, Issue 4, March 1999
2. Anderson, Grant, 1988, Privatizing management of solid waste in developing countries, the Malaysian experience, http://www.idrc.ca
3. Asomani-Boateng, R. and Haight Murray, 1999, Reusing organic solid waste in urban farming in African cities: A challenge for urban planners, School of Urban and Regional Planning, University of Waterloo, Ontario, Canada
4. Ayamuang, Nongnut Foppes and Wongpanit, May 2000: A successful waste recycling RISE-AT, Chiang Mai. Thailand
5. Center for Research in Environmental Economics and Political Decision making, CREED working paper, Series No: 24, http://www.iied.org/creed/
6. Chua, Thia-Eng and Garces, Len R., 1992, Waste Management in the Coastal areas of the ASEAN region, Association of Southeast Asian Nations/United States Coastal resources Management Project Conference Proceedings
7. Darmastuti, Lorina RR, 2000, Community participation in solid waste management, case study Sukamantri Kampong, Majalaya City
8. Einsiedel, Nathaniel V., 1998, Final disposal of municipal solid waste in Asia: An Overview. UNDP/UNCHS Urban Management Program, August 1998
9. Habitat, 1996, An Urbanizing World: Global Report on Human Settlement, Oxford University Press.
10. Hoornweg, Daniel, 1998, What a waste: Solid waste management in Asia, The World bank, Urban Environmental Management
11. http://www.makingcitieswork.org/archive.asp
12. http://www.urckarachi.org/home.htm
13. Jayamanne, 1999, Pilot Scale Market Garbage Disposal Project-Kirulapone, NERD Seminar, Colombo Sri Lanka, August, 1999.
14. Johannessen, Lars Mikkel and Boyer, Gabriela, 1999,"Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America". Urban and Local Government Working Paper Series #3, World Bank, Washington, DC, 1999a
15. Johannessen, Lars Mikkel and Boyer, Gabriela, June 1999, Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America Urban Development Division Waste Management Anchor Team, World Bank
16. Kathrin Senner, 2000, Mukuru Recycling Centre - A Gender Evaluation, Nairobi, Kenya, January, 2000.

17. Martin Weinschenk-Foerster, 1996, "Chiang mai's Solid Waste Management and its Problems. Working summary, RISE-AT, Chiang Mai, Thailand, pp 128
18. Mathur, O.P., 1994, Solid waste practices in India: Problems and prospects, urban India XIV, New Delhi, India.
19. Mosha, A. C., 1990, Urbanisation and environment - Case study: Dar es Salaam. In: International Society of City and Regional Planners (ed.), The Environment and the City Case Studies. Amsterdam: ISCRP
20. Nairobi City Council statistics, Nairobi City Council and African Urban Quarterly, May 1992.
21. Nwaka, G. I., 1990, Urban planning and environmental protection in Nigeria. International Society of City and Regional Planners (ed.), The Environment and the City Case Studies. Amsterdam: ISCRP.
22. Report on Seventh Meeting Of The Urban Think Tank 'Effective Solid Waste Management With The Participation Of Waste Producers', Water and Sanitation Program, January 1999
23. Rosario, Anselm, 1994, Decentralized solid waste management approach, 20th WEDC Conference: Colombo, Sri Lanka, 1994
24. UNCHS, 2000, EXNORA, Community participation for a clean environment, Madras, India, Best Practices database. http://www.bestpractices.org
25. UNCHS, 2000, Improved Waste Management and Mobility in Calcutta, India, Best practices database, Source: Best practices database, Improved Waste Management and Mobility in Calcutta India, Water and Sanitation program, January 1999, Effective Solid Waste Management With The Participation Of Waste Producers, Calcutta, India. http://www.bestpractices.org
26. UNCHS, 2000, Integrated solid waste collection system in the city of Olangapo, Philippines, Best practices database. http://www.bestpractices.org
27. UNCHS, 2000,Resource Recovery Program in Metro Manila, Philippines, Best practices database, http://www.bestpractices.org
28. United Nations (UN) Population Division, 1996, World Urbanization Prospects, 1996 revision
29. UNDP, 1997, Human Development Report, Oxfort University Press, New York, USA
30. Waste Management in the Coastal areas of the ASEAN region, 1992
31. Water and Sanitation Program, January 1999, Effective Solid Waste Management With The Participation Of Waste Producers, Calcutta, India, http://www.wsp.org
32. Weinschenk-Foerster, Martin, 1996, "Chiang mai's Solid Waste Management and its Problems. 128pp. Working summary, RISE-AT, Chiang Mai, Thailand.