2.1 Definition of waste

Waste in itself is a term that is surprisingly difficult to define with precision, and failure to define it precisely can cause some problems. In general we can say that "waste" is a material that is perceived as having no value to the person or organization that owns it *(Rushbrook, 1988)*. Waste is defined as any discharge of unwanted material arising from human activity *(Harvey, 1983)*. It is something for which we have no future use and which we wish to get rid of *(Rose, 1995)*. A waste is a material, which is thrown away as worthless. The entire concept of waste is subjected to the value judgment of the primary owner or potential consumer. A waste is viewed as discarded material, which has no consumer value to the person abandoning it *(Cointreau, 1982)*. 'Waste' is a term, which most people understand, yet a formal definition is far from straightforward. The World Health Organisation (WHO) defines waste as 'something which the owner no longer wants at a given place and time and which has no current perceived market value. It seems to us that waste is best defined by reference to the person who wishes to dispose of and based on what happens to it afterwards. Materials become identified as waste when somebody regards it as valueless and wants to get rid of it.

This concept is recognized in the definition given in the Malaysian Control of Pollution Act 1974. Section 30(1) which defines ' control waste' (i.e. household, commercial and industrial waste) as including:

(a) any substances which constitutes a scrap material or an effluent or other unwanted surplus substance arising from the application of any process; and

(b) any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled'. The Act goes on to say that 'any thing which is discarded or otherwise dealt with as if were waste shall be presumed to be waste unless the contrary is proved'(*Royal Commission on Environmental Pollution,1985).* Under Malaysian Environmental Quality Act and Regulations 1974, "waste" includes any matter prescribed to be waste and any matter, whether liquid, solid, gaseous, or radioactive, which is discharged, emitted, or deposited in the environment in such volume, composition or manner as to cause an alteration of the environment. Weston (1970) classified waste into three main categories, *i.e.* solid, liquid and gaseous waste. Within each category there are various subdivisions (*Table 2.1).*

In "A Guideline Book on The Storage, Collection, Transport and Disposal of Solid Waste in Malaysia", waste is defined as "waste arising from human and animal activities that are normally solid and that are discarded as useless or unwanted are termed as solid waste (DEMSTE, 1995).

Sweden considers waste to fall into three categories: consumption waste, production wastes and hazardous wastes, as:

1. Consumption wastes

   Waste derived from the use and consumption of consumer and capital goods, including services. Examples include household wastes, non-sector specific wastes, sewage, construction and demolition wastes, parks and garden wastes, sewage sludge and scrap vehicles.

2. Production wastes

   Wastes arising as a consequence of industrial production. Examples include industrial wastes and mining wastes.

Table 2.1: Waste classification

I Solid Waste	II Solid Waste
A. Putrescibles Household garbage Vegetable and fruit processing wastes Animal manure, Death animal meat, Poultry and Seafood processing wastes Others, Not Elsewhere classified	J. Sludges Chlorinated Brominated Fluorinated Acid, Alkaline Water-Reactive (Unhydrolyzed) Air-Reactive Miscellaneous Organic Metallic Inorganic Non-Metallic Inorganic K. Demolition and Construction L. Abandoned Vehicles M. Radiological Wastes
B. Bulky Combustibles Wood, Paper and Products Cloth and Plastics Rubber Leather Yard and Street Wastes C. Bulky Non-Combustibles Metals Minerals D. Small Combustibles Wood, Paper and Products Cloths and Plastics Rubber and Leather Yard and Street Wastes E. Small Non-Combustibles Metal Minerals Ashes F. Non-Empty Cans, Bottles and Drums G. Gas Cylinders H. Powder and Dusts Organic Metallic Inorganic Non-Metallic Inorganic Explosive I. Pathological Wastes Cloth, Paper and Plastic Animal and human Wastes Instruments and Utensils	**II. Liquid Wastes** A. Wastewaters B. Contaminated Waters Chlorinated Brominated Fluorinated Acid Alkaline Putrescibles Insoluble oils Soluble oils Toxic Organics Soluble Metals Others, NEC C. Liquid Organics Chlorinated, Brominated Fluorinated, Sulfurated Acid, Alkaline Water-Reactive (Unhydrolyzed) Shock-Reactive Soluble Metals D. Tars E. Slurries **III. Gaseous Wastes** A. Odorous B. Particulate Combustibles C. Organic Vapors, Acid Gases

SOURCE: Weston, (1970)

3. Hazardous wastes

   Wastes, which require special handling owing to its harmful effects on human health and the environments. Theses are usually industrial wastes *(Warmer Bulletin 66).*

In Japan, Sapporo, (the fifth largest city in Japan with 1.65 million population) waste are classified into two categories to facilitate incineration and landfill. One category is "combustible waste: including kitchen waste. The other category consists of non-combustible (glass, metal, etc.) and bulky items *(Matsuto, 1993).*

2.2 Definition of solid waste

What is a solid waste? Solid waste is any solid material in the material flow pattern that is rejected by society. Solid wastes arise from unusable residues in raw materials, leftover, rejects and scrap from process operations, scrap packaging materials and even the saleable products *(Read, 1998).* Cointreau (1982) in his technical paper "Environmental Management of Urban Solid Waste in Developing Countries" defines solid waste as wastes, which are neither wastewater discharges nor atmospheric emissions; so, solid waste may therefore be a semi-solid, solid or even a liquid. Solid waste is all waste except that which is discharged to the atmosphere, or via pipelines or sewers to effluent treatment works, or direct to surface waters. Thus, many materials are categorized under the broad heading of solid waste *(refer* Table *2.2).* It may be a solid, a sludge or slurry or liquid of a kind not suitable for direct discharge to an effluent treatment work or to surface water, e.g. waste oil or solvent. Wastes from agriculture, forestry and mining are

Table 2.2 Materials categorized under solid waste

Refuse (Solid Wastes)	Garbage	Waste from the preparation, cooking and serving of food Market refuse, waste from the handling, storage and sale of products and meats	From: Households, Institutions and Commercial concerns such as hotels, stores, restaurants, market, etc.
	Rubbish	Combustible (primarily organic): Paper, cardboard, cartons, wood, Plastic, Rags, Cloths bedding	
		Non-combustible (primarily inorganic): Metals, tin cans, metal foils, dirt, bricks, ceramics, crockery, glass, bottles other mineral refuse	
	Ashes	Residue from fires for cooking and for heating building , cinders	
	Bulky wastes	Large auto parts, tires, stoves, refrigerators, other large appliances, Furniture, large crates, trees, branches, palm, stumps, flotage	From: Streets, sidewalks, alleys, vacant lots, etc.
	Street refuse	Street sweeping, dirt, Leaves, Catch basin dirt, Contents of litter receptacles	
	Dead animals	Small animals: Cats, dogs, poultry, etc. Large animals: horses, cows, etc.	
	Abandoned vehicles	Automobiles, trucks	
	Construction and demolition waste	Lumber, roofing and sheating scraps, Rubble, broken concrete plaster, etc. Conduit, pipe, wire, insulation, etc.	From : Factories, Power Plants, Etc.
	Industrial refuse	Solid wastes resulting from industry processes and manufacturing operation such as: food-processing wastes, boiler house cinders, wood, plastic and metal scraps, and shavings, etc.	
	Special wastes	Hazardous wastes: pathological wastes, explosives, radioactive materials, Security wastes: confidential documents, negotiable papers, etc.	Households hospital, stores, industry, etc.
	Animal and agricultural wastes	Manures, crop residues	Farms, feed lots
	Sewage treatment residues	Coarse screening, grit, septic tank sludge, dewatered sludge	Sewage treatment plants, septic tanks

SOURCE: Lardinios, (1993)

not included. The United States Environmental protection Agency (USEPA) defines solid waste as "useless, unwanted, or discarded materials with insufficient liquid content to be free flowing *(Swarup 1992)*. The U.S. Congress, in the 1976 Resource Conservation Recovery Act (RCRA), defines solid waste as " any garbage, refuse, sludge from a waste treatment plant, or air pollution control facility and discarded materials, including solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial, mining and agricultural operations and community activities *(Stanley, 1993)*. Alan (1996) defines solid waste as "all material of solid or semi solid character that the possessor no longer considers of sufficient value to retain. From the technical point of view, it is a material having a significant angle of repose. The angle that the surface of the pile makes to horizontal is the angle of repose. The angle of repose is a characteristic of the fluidity of a substance. A material that does not exhibit an angle of repose will assume a flat horizontal surface if allowed to stand unconstrained. A significant angle of repose is subjective but can generally be viewed as that angle that will permit the material to be handled by solid handling equipment such as conveyors, front-end loaders, and shovels. If it has sufficient fluid properties that prevent forming a pile without containment walls, it generally considered being a liquid waste, not a solid waste. This is an important distinction since it is difficult to draw a clear line between what is solid waste and what is liquid when working at the interface between the two *(Preffer, 1992)*.

Municipal Solid Waste (MSW) comprises the accumulated discards of society's activities. For municipal solid waste, more specific terms are applied to the putrescible (biodegradable) food waste, called garbage, and the non- putrescible solid waste, referred to as waste *(Swarup, 1992)*. There is a common tendency to associate solid waste with garbage. MSW is considered to have generated if it is placed at curbside or in a receptacle such as a Dumpster for picker, or if generator takes it to another site for disposal or other waste management alternative employed. MSW is waste produced by household or by commercial production activities whose waste is similar to that of household. In general terms, solid waste (sometimes called refuse) can be defined as waste not transported by water, that has been rejected for further use *(Henry, 1996)*. For the residents, municipal solid waste used to be considered as any solid matter which was discarded as no longer being useful in their daily life activity. All matter, which is disposed of onto land in any form, is considered "solid waste" *(James, 1993)*. It can be said that solid wastes vary in size, form, origin, and physical composition. They are often placed into three categories; solid, liquid and gaseous. It is also common to classify solid waste materials by their origins, usually those derived from domestic, municipal, commercial and industrial sources *(Cargo, 1977)*. In Environmental Impact Assessment Guidelines for Malaysian Municipal Solid Waste and Sewage Treatment and Disposal Project, MSW is defined as "combined domestic, commercial, and institutional solid waste generated in a given municipality/ locality". It includes all waste normally collected from residences, small businesses, retail stores, restaurants, markets, offices, hotels, print shops, auto repair shops and the like and institutions (schools, communities, public facilities, and the like). It does not include scheduled waste generated by manufacturing enterprises. However, MSW will contain quantities of certain scheduled waste rising from homes, offices and institution.

Definitions of MSW vary across Europe. Some programmes define MSW as just household and assimilated (light commercial) waste, while other programmes include industrial waste (either on a voluntary or obligatory basis), hazardous waste and construction waste (see Table 2. 3).

Table 2.3 : Difference in definition of MSW in Europe

Programme	Household	Assimilated *	Industrial	Hazardous	Construction	Agriculture
Copenhagen, DK			Obligatory			
Helsinki, FI			Voluntary			
Malmo, SE			Obligatory			
Hampshire, UK						
Pamplona, E			Voluntary			
Brescia, I			Obligatory			
Prato, I						
Vienna, A			Obligatory			
Lahn-Dill-Kreis, D			Voluntary			
Saarbucken, D			Voluntary			
Zurich, CH			Voluntary			

* Assimilated waste is described as similar in composition as household waste and includes most commercial wastes. Grey areas represent waste-streams included within each Municipality's definition of MSW

SOURCE: Warmer Bulletin 65, 1999

Since there is no standard international definition of MSW covering all waste generated by the different sources, the working definition of MSW relates to waste collected directly or indirectly by municipal authorities *(Arang, 1994)*.

2.3 Definition of urban solid waste

Urban solid waste is defined as: material for which the primary generator or user abandoning the material within the urban area requires paying compensation upon abandonment. In addition, it qualifies as an urban solid waste if it is generally perceived by society as being within the responsibilities of the municipality to collect and dispose of *(Cointreau, 1982)*. The categories of materials discarded in urban areas and generally viewed as a municipal responsibility include: household garbage and rubbish, residential ashes, commercial refuse, institutional refuse, construction and demolition debris, street cleaning wastes, bulky wastes, abandoned vehicles, and sanitation residues.

Solid waste from mining and agriculture are typically generated outside an urban area, and do not fall within the generally perceived responsibilities of a municipality. Industrial solid wastes require the attention of a municipality, and fall within municipal responsibility to manage in a manner that protects the public health and safety. However, industrial wastes may be collected and hauled by the private sector.

Commercial refuse consists of waste from stores, offices, fuel service stations, restaurants, warehouses and hotels. The waste typically consists of packaging and container materials, used office supplies, and food wastes. In developing countries, markets may contribute the major portion of this waste category's refuse. Markets, involve many vendors with very small stalls, there is not adequate individual or communal storage of the refuse while awaiting collection service. Most commercial refuse in developing countries is handled by the municipality. Exceptions occur in the case of very large hotels and major commercial offices, which are prone to engage a private hauler.

Institutional refuse includes school, government offices, hospitals, police barracks and religious buildings. Where the institution involves residents, such as in barracks, the wastes are similar to those from households. However, this category generally involves a large portion of paper rather than food.

Hospital wastes, in developing countries are sometimes handled privately by hospital and/or its contractor. Where they are not separately collected and disposed of, efforts to isolate them should be arranged by the municipality. Outside the case of hospitals, most institutional wastes in developing countries are directly managed by the municipality. Typically a separate system of collection is employed from that used to service households and commercial enterprises; and most often, the system involves portable metal bins of 6 to 8 cubic meter size which can be lifted onto a truck body or trailer for hauling.

Street sweepings of waste always include, sand, grit, dirt and litter from normal street sweepings and catch basin cleaning. During the fall, leaves may be the primary component or the refuse stream, depending on the degree of urbanization and the policy regarding leaf picker or burning. However, in developing countries it may also contain appreciable amounts of household refuse drain cleanings, human faecal matter and animal manure. In India, where the primary method of refuse disposal from households and commercial establishments is "placement" of wastes in individual or communal heaps along the roadside, street sweeping includes a large portion of kitchen waste and paper.

Household hazardous waste (HHW) can be defined as any material discarded by a household which is difficult to dispose of, or which puts human health, animals, plants and environment at risk because of its chemical or biological nature. Household hazardous waste included pesticides, herbicides, household cleaning products, oil-based paints and thinners, antifreeze, batteries and automotive products, such as gasoline. Even businesses in housing areas such as metal finishing, gas stations, auto repair shops, dry cleaners, and photo developers produce many toxic waste products. These by-products include sulfuric acid, heavy metals found in batteries, and silver-bearing waste, which comes from photo finishers, printers and clinic. Photo processing also creates organic chemicals, chromium compounds, phosphates, and ammonium compounds. Even cyanide can be a by-product, resulting from electroplating and other surface-treatment processes. These hazardous waste, could pollute ground water, contaminate soil, or cause explosions or fire.

Construction and demolition debris depends on the resources generally used in a given region or country for purposes of construction. Major multi story buildings are not typically a problem to developing countries in terms of construction and demolition debris, since these activities have sufficient capital backing and public exposure to provide an incentive for the owner/ contractor to contain and haul the waste. However, activities related to small buildings, particularly where the construction material is clay soil, bricks, concrete, plumbing, electrical wiring, and so on, can contribute significant quantities of waste to the municipal refuse. Very often, large heaps of soil and stones are dumped along the streets with the assumption that the municipality has the responsibility to collect and haul it. The quantity of the material associated with building demolition and construction can be highly variable, due to the close correlation of the construction industry with thew general economy of an area. Special methods of collection are needed; design of vehicle chassis should take the extra weight into consideration.

Industrial wastes come from processing and non-processing industries, as well as utilities. Packaging materials, food wastes, spoiled metal, plastic and textiles, fuel burning residuals, and spent processing chemicals are among the wastes within this category. The composition is site-specific, and depends on the natural resources and markets, which provide the base for a given city's industrial activity. Small-scale industrial enterprises generally discharge their solid wastes into the collective milieu of municipal refuse. Large-scale industries, however, are usually either required to arrange for a private hauler or to pay to the municipality for special service. In either event, most municipalities in developing countries apparently allow industrial waste to be disposed within their landfills; and generally without charging any tipping fee to cover the costs of disposal. In United States of America, industrial refuse is not treated as part of municipal refuse; its quantity is about three times that of municipal refuse; and between 10 and 15% is considered hazardous.

Special wastes or healthcare waste are the solid and semisolid materials generated by special facilities such as hospitals and research laboratories. These wastes may include explosive substances, toxic chemicals, radioactive materials, or pathological materials. Because of the hazardous nature of these materials, they are not permitted in the general waste stream, but require special collection, handling, and disposal, depending on the exact nature of the material.

Great many materials have been categorized under the broad heading of urban solid wastes. The classification is generally applied to an extremely heterogeneous group of materials encompassing for more constituents' elements than most people realize. Failure to keep this point in the mind, or to clearly define the scope of the term urban solid waste, can lead to confusion and misunderstanding on the nature and magnitude of the urban solid waste management problem. In general, urban solid wastes are:

I. heterogeneous-it is in a mixture form, consisting of a infinite variety of materials and,

II. not in pure form-it is contaminated with other undesirable *(Lohani, 1982)*.

2.4 Waste generation rate

Waste generation, both domestic and industrial, continues to increase worldwide in tandem with growth in resources consumption. Throughout this century, economic progress and the population increase in the developed nations had led to an increase in the amount of waste produced per person(Phillips, 1997). The rate of generation varied greatly depending on the premises (house, shops, food stalls, and restaurant), affluence of the population(low income or high income), occupation or business. This had then translated into higher purchasing power for consumer goods). Rapid urban population growth had led to an increase in number of people living on each unit of urban land. More and more people are coming to city because of the attractions of the city for employment or a better quality of life, or the lack of opportunity in the rural area. Faster than ever before, the human world is becoming an urban world. The process of urbanization and industrialization is bringing significant transformations of the life styles of urban residents. The modern society regarded as rational, western, dynamic, profit orientated and a product of colonial import generates more MSW than traditional society. This dramatic growth in the population and size of urban areas has resulted in overwhelming of amount solid waste generated by urban residents. The more urbanized and affluent the community, the more complex and increased volume of wastes generated. In developed countries, per capita waste generation increased nearly three-fold over the last two decades, reaching a level five to six times higher than that in developing countries. The quantities of solid waste generated by each inhabitant in developing countries is less than in the developed world. This is due to, low general prosperity and level of consumption by the population, and the extensive separation, by householders of waste materials for reuse before they enter the waste collection and disposal system (*Holmes, 1984*).

In 1995, the total amount of municipal waste generated throughout Malaysia was 5.5 million tonnes and of this 80% was domestic waste (about 12,000 tonnes/day) and the rest (about 3, 000 tonnes/day) was commercial waste. Currently each Malaysian had produced 1.20 kg of waste per day. The amount of municipal waste generated had increased from 246, 006 tonnes (1997) to 249, 593 tonnes (1998), commercial waste from factories, had declined from 98, 976 to 70, 458 tonnes within the same peroid (NST, 8/6/1999).

In Kuala Lumpur, the solid waste generated since 1990 until 1996 had increased. The situation is becoming more critical because the population density (5, 340 people living per sq km) and the population growth (average 2.7% per annum) with urban and foreign workers which total to 1.8 millions. In 1997 it was estimated around 600 tonnes of refuse were collected daily but in 1986 the amount had increased to 2,000 tonnes (Sham Sani, 1988). Today with the population of 2.2 million and with 400,000 households in Kuala Lumpur (The Star, 12/3/1997), the amount of solid waste generated had increased to 3, 500 tonnes daily (The Star, 10/12/1997). Furthermore, the increasing number of urban squatter settlements in Federal Territory (refer to Table 2.4) exerts extra strain on environment in the form of more garbage and sewage.

Table 2.4 Squatter units in the Federal Territory of Kuala Lumpur.

Squatter units (residential and non-residential)					
	Parliamentary constituencies	Squatter units	%	Household (families)	%
1	Kepong	3,932	9.67	4,280	9.32
2	Batu	4,256	10.47	4,892	10.65
3	Wangsa Maju	4.044	9.95	4,660	10.14
4	Segambut	3,347	8.23	3,553	7.74
5	Titiwangsa	4,602	11.32	4,950	10.78
6	Bukut Bintang	2,507	6.17	2,757	6.00
7	Lembah Pantai	6,763	16.64	6,983	15.20
8	Seputih	2,809	6.91	3,477	7.57
9	Cheras	4,278	10.52	5,440	11.84
10	Bandar Tun Razak	4,112	10.12	4,942	10.76
	Total	40.650*	100.00	45,934	100

SOURCE: New Straits Times, 16/4/1997, * including non-residential units

The Selangor states with 3.94 million people (2001) living in the local council's administrative area has highest population growth rate (6.02%). Thus, in 1998, Selangor had the highest solid waste generation of 2375 tonnes/day followed by Kuala Lumpur at 2257 tonnes/day while Labuan had the lowest solid waste generation of only 46 tonnes/day.

In America, each person discards 3.6 kg a day, almost twice as much as the average in Germany *(Noel, 1994)*. The U.S. leads the world in waste production. For example, the quantity of municipal waste in the United States has grown steadily over the past several decades. It had increased from 88 million tonnes in 1960, to 152 million tonnes in 1980, to about 209 million tonnes in 1994. This is enough to fill a convoy of garbage trucks stretching eight times around the globe.

In Canada, some 24.6 million tonnes of waste was generated in 1996, representing 0.83 kg/capita, down from 0.99 kg capita in 1992, a significant drop of 7 per cent in four years (*Warmer Bulletin 74, 2000*).

European Union members generate 180 million tonnes per annum (Mtpa) of MSW. Germany, France, Italy and United Kingdom generate more than 72 per cent of Europe's MSW. Germany alone generates nearly a quarter of the MSW produced in the European Union. In Phare countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia), the amount of MSW generated were 37 Mt in 1997 and was 385 kg per person *(Warmer Bulletin 76, 2001).* In Belgium, household waste varies from 0.9kg/day/person in rural areas to 1.5 kg/day/person in large cities *(Fontana., 1997).* In the mid-90's, a rough estimation shows that Western Europe, generated proximately 132 million tonnes(400 kg per capita) *(Warmer Bulletin 76, 2001).* Sweden, with population of 8.8 million people, generated more than 3.5 million tonnes of household waste each year(Mtpa)*(Warmer Bulletin 66, 1999*). Manila Metropolitan generates at least 3,000 tonnes of solid waste daily*(Warmer Bulletin 67,1999*). Ho Chi Minh City with 5 million people generates around 3, 500 tonnes per day (tpd)*(Warmer Bulletin 67,1999).*

Accra, Ghana's capital city (population 1.4 million), generates approximately 750-800 tonnes of refuse per day (tpd), with a per capita generation rate of between 0.5-0.6 kg/day. The daily generation of MSW in the metropolis is expected to increase by 3.7 per cent pa *(Warmer Bulletin 69, 1999).* In Guadalajara Metropolitan Zone, Mexico the daily per capita MSW ranged from 356 to 659 g with a mean value of 508g; with an estimated population of 3.43 million, the corresponding mean daily total MSW generation was 1,740 tonnes.

If current trends continue, the world may see a five-fold increase in waste generation by the year 2025. Cargo, (1977) had concluded that: (1) the average generation rate by dwelling type decreases as the number of persons per dwelling unit increases; (2) the quantity of solid wastes generated from a dwelling unit depends upon the number of occupants, not the dwelling unit; and (3) the average solid waste contributed per person is constant within each of the classes of dwelling units (single-family, multi-family, and apartment). Although the per capita rate of waste generation in developing countries is less than half that of industrialized countries, the income levels in these countries are much lower compared to the income levels in industrialized countries. Contrary to the popular belief, the volume of solid waste generated declines as a percentage of output, as development proceeds. This means that the developing countries: (1) are generating relatively more solid waste per unit of output than the industrialized countries; and (2) are relatively more constrained, with respect to their resources, in coping with solid waste collection and disposal. In economically less developed countries the amount of waste generated also varies according to the income group from which it originates. The richer the citizens, the more waste is generated,

- high-income groups: >1 kg/capita/day
- middle-income groups: 0.5-1 kg/capita/day
- low-income groups:<0.5 kg/capita/day (Lardinois, 1993).

In a recent research aimed at the determination of household solid waste in Kuwait, Koushki(1995), calibrated a number of two-way and three-way desegregated crossassification models. These models successfully predicted the quantity of waste enerated daily as a function of their socioeconomic characteristics.

Household waste has an energy content (net calorific value of 7500 to 10,000 J/kg) which could be used for electricity (*Fontana, 1997*) Table 2.5 shows the average alorific value of waste material found in municipal solid waste.

Table 2.5: Average calorific values of waste materials in MSW.

Items	**(cv) as received* MJ/kg**
dust and cinders	9.6
paper	14.6
vegetable	6.7
metals	nil
glass	nil
rag	16.0
plastic	37.0
unclassified(wood, shoes etc.)	17.0

*moisture content typically 20-30% by weight.

SOURCE: Inge Lardinois, 1993.

The combustible fraction in Japanese MSW continues to rise *(see Table 2.6)*. The average ower calorific value of this fraction increased from just over five mega joules per kg MJ/kg) in 1975 to almost nine MJ/kg in 1997.

Table 2.6: MSW composition in Japan

MSW fraction	**1975** composition(per cent)	**1997** composition (per cent)
Paper / cardboard	46.3	54.4
Wood / bamboo	5.6	4.0
Incombustibles	10.7	2.8
Plastics	12.7	23.4
Putrescibles	18.6	11.2
Miscellaneous	6.1	4.2
Total	100	100

SOURCE: Warmer Bulletin 70, 2000

Table 2.7 shows the municipal solid waste composition and calorific values for high and medium income areas for five selected urban in Malaysia. A comparative data of MSW composition and calorific value by residence type in Kuala Lumpur is given in Table 2.8. The more recent detail of calorific value of MSW (wet basis) for different residential, office and commercial areas in Kuala Lumpur are presented in Table 2.9(a), 2.9(b), 2.10 (a) and Table 2. 10(b).

2.5 Waste Characteristic

2.5.1 Waste density

Under the heading of waste characteristics, these subjects are discussed: (i) waste density; (ii) waste composition; (iii) moisture content; and (iv) size distribution of waste materials. Where waste production is high, density tends to be low and vice versa. Lower density values associated with industrialized countries are related to the high percentage of non-putrescible, such as paper, plastics, glass and metals, which often result from packaging of consumer goods. These materials have large void spaces, low moisture content, and low-density values. In addition to composition, the density of solid waste in developed countries tends to be largely unchanged between the point of generator storage and the collection vehicle. In Jakarta, Indonesia, measurements from a World Bank sponsóred pilot project showed refuse densities of about 200 kg/m^3 in the standardized household bins; 370 kg/ m^3 in the pushcarts; and was 600 kg/ m^3 after being compacted in the hand-loaded baler located at the pilot transfer station. In Calcutta, India, refuse exhibited densities of about 550 to 600 kg/cubic meter in the non-compaction collection vehicle. After disposal by open dumping, whereby no compaction was performed, and resting within the dump for six months, the refuse had naturally consolidated to a density of about

Table: 2.7 MSW composition and calorific value by high and medium income areas

		High Income Areas Petaling Jaya	Kuala Lumpur	Shah Alam	Medium Income Areas Seremban	Bangi
Municipal solid waste		36.5	45.7	47.8	38.0	40.0
Plastic	P	16.4	9.0	14.0	10.0	15.0
Paper/cardboard		27.0	29.9	20.6	20.0	18.0
Fabric		3.1	2.1	2.4	8.0	6.0
Wood						
Others						
Subtotal	B	83.0	86.7	84.8	76.0	79.0
Glass		3.1	3.9	4.3	4.0	4.0
Metals		3.9	5.1	6.9	10.0	4.0
Miscellaneous		10.0	4.3	4.0	10.0	13.0
Subtotal	Ir	17.0	13.3	15.2	24.0	21.0
Total		100.0	100.0	100.0	100.0	100.0
Moisture	W	(62.9)	61.5	65.0	63.0	60.0
Dry content	Ir+B	37.1	38.5	35.0	37.0	40.0
Noncombustible (Dry)	Ir	13.4	11.4	13.3	19.9	16.0
Volatile solid except noncombustible *	B	23.8	27.1	21.7	17.1	23.7
Plastic (Dry basis)	P	13.1	7.2	11.2	8.0	12.0
Formula						
(1) 45B-6W	kcal/kg	691	849	587	393	705
(2) 45(B-P)+80P-6W	kcal/kg	1,150	1,101	979	673	1,125
When dewater 10%	kcal/kg	1,344	1,290	1,154	815	1,316

* MJ/kg

SOURCE: Ministry of Housing and Local Government Malaysia, July, 2000.

ble: 2.8 MSW composition and calorific value by type of places in Kuala Lumpur

ms	High rise residential	Bunglow, Terrace	Commercial	Market	Hotel	Hawker	Office
unisipal solid aste	44.6	49.2	42.5	61.3	30.0	55.6	22.3
astic	20.2	13.9	22.0	9.0	16.3	6.5	18.8
per/ rdboard	20.9	23.8	22.0	25.2	41.5	22.7	50.1
bic	3.1	2.1	1.8	0.5	0.6	0.1	0.7
ood	1.8	1.2	1.5	1.7	0.6	0.3	0.5
hers	2.7	2.0	0.6	0.1	0.9	0.1	1.2
btotal	93.3	92.2	91.3	97.8	89.9	85.3	93.6
ass	3.0	2.6	1.4	0.3	3.7	1.3	0.7
etals	1.3	2.3	5.8	1.5	1.5	2.4	4.4
iscellaneous	2.4	2.7	1.5	0.5	4.9	1.0	1.3
btotal	6.7	7.6	8.7	2.3	10.1	4.7	6.4
tal	100	99.8	100	100.1	100	90.0	100
oisture	51.1	48.7	34.1	38.2	27.2	31.4	36.2
00-moisture	48.9	51.3	65.9	61.8	72.8	68.6	63.8
oncombustible ry)	5.8	6.5	7.7	2.0	8.3	4.2	5.6
olatile solid xcept oncombustible	43.1	44.8	58.2	59.8	64.5	64.4	58.2
astic (dry)	16.2	11.1	17.6	7.2	13.0	5.2	15.0
eight (%)	25.7	33.5	8.6	4.3	4.9	13.0	10.0
alorific value er item	6,933	6,077	10,961	9,594	10,970	10,148	9,474
ng/l	1,782	2,036	943	413	538	1,319	947
w calorific alue	1,656	1,452	2,619	2,292	2,621	2,424	2,26

MJ/kg

OURCE: Ministry of Housing and Local Government Malaysia, July , 2001.

Table 2.9(a) Calorific value of MSW (wet basis) for different areas in Kuala Lumpur

	INSTITUTIONAL (OFFICE)						COMMERCIAL				
Low CV	CATEGORIES	% Comp	Moisture content	Energy Btu/kg	Btu		% Comp	Moisture content	Energy Btu/kg	Btu	
	1. Food waste & organics	58.7	75	1676	98353		79	74.4	1716	135543	
	2. Mix paper	7.9	55.1	2966	23431		5.1	48.6	3395	17316	
	3. Plastics	16.1	23.4	9496	152892		9.1	29.1	8790	79987	
	4. Textiles	0.8	50.5	3931	3144		0.7	45.5	4328	3029	
	5. Rubber & leather	0.2	14.3	6152	1230		0.7	10.1	6454	4518	
	6. Wood	0.2	31.7	4887	977		1.9	27.3	5202	9884	
	7. Yard waste	9.8	72.2	1846	18088		0.7	88.9	737	516	
	8. Fine	0.0					0.0				
		93.7			298116	Btu	**97.2**			250793	Btu
					2981	Btu/lb				2508	Btu/lb
					1654	kcal/kg				**1392**	kcal/kg
high CV	CATEGORIES	% Comp	Moisture content	Energy Btu/kg	Btu		% Comp	Moisture content	Energy Btu/kg	Btu	
	1. Food waste & organics	58.7	75	2055	120647		79	74.4	2105	166267	
	2. Mix paper	7.9	55.1	3972	31378		5.1	48.6	4547	23189	
	3. Plastics	16.1	23.4	15999	257583		9.1	29.1	14808	134757	
	4. Textiles	0.8	50.5	4653	3723		0.7	45.5	5123	3586	
	5. Rubber & leather	0.2	14.3	6494	1299		0.7	10.1	6812	4769	
	6. Wood	0.2	31.7	5220	1044		1.9	27.3	5557	10557	
	7. Yard waste	9.8	72.2	1982	19421		0.7	88.9	791	554	
	8. Fine	0.0					0.0				
		93.7			435095	Btu	**97.2**			343678	Btu
					43251	Btu/lb				3437	Btu/lb
					2415	kcal/kg				**1907**	kcal/kg

SOURCE: Ministry of Housing and Local Government Malaysia, July, 2001.

Table 2.9(b) Calorific value of MSW (wet basis) for different areas in Kuala Lumpur

	INSTITUTIONAL (OFFICE)					COMMERCIAL			
avg. CV	CATEGORIES	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu
	1. food waste & organics	58.7	75.0	1910	112132	79.0	74.4	1956	154532
	2. mix paper	7.9	55.1	3324	26261	5.1	48.6	3805	19407
	3. plastics	16.1	23.4	13721	220912	9.1	29.1	12700	115572
	4. textiles	0.8	50.5	4352	3482	0.7	45.5	4792	3354
	5. rubber & leather	0.2	14.3	6961	1392	0.7	10.1	7302	5111
	6. wood	0.2	31.7	5070	1014	1.9	27.3	5396	10253
	7. yard waste	9.8	72.2	1924	18854	0.7	88.9	768	538
	8. fine	0.0				0.0			
		93.7			384047 Btu 3840 Btu/lb **2131** kcal/kg	**97.2**			308768 Btu 3088 Btu/lb **1713.5** kcal/kg

SOURCE: Ministry of Housing and Local Government Malaysia, July, 2001.

Table 2.10(a) Calorific value of MSW(wet basis) for office and commercial areas in Kuala Lumpur

		RESIDENTIAL-HIGH				RESIDENTIAL-MEDIUM				RESIDENTIAL-LOW			
Low CV	CATEGORIES	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu
	1. Food waste & organics	62	60.9	2621	162472	70.8	75	1676	118627	71.6	66.4	2252	161236
	2. Mix paper	8.1	51.6	3197	25897	5.1	44.1	3693	18832	5.8	18	5417	31417
	3. Plastics	9.3	18.7	10079	93735	11.3	13.8	10687	12758	13.3	14	10662	141801
	4. Textiles	2.2	53.3	3708	8158	1.3	33.7	5265	6844	2.4	53.7	3676	8824
	5. Rubber & leather	0.8	25.8	5327	4261	0.6	7.9	6612	3967	0.5	14.4	6145	3072
	6. Wood	0.5	34.6	4680	2340	0.4	28.1	5145	2058	0.5	24	5438	2719
	7. Yard waste	11.8	77	1527	18019	4.7	61.8	2536	11920	1.2	54.9	2994	3593
	8. Fine	0.0				0.0				0.0			
		94.7			314882 Btu	**94.2**			283006 Btu	**95.3**			352663 Btu
					3149 Btu/lb				2830 Btu/lb				3527 Btu/lb
					1747 kcal/kg				**1571** kcal/kg				**1957** kcal/kg
high CV	CATEGORIES	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu
	1. Food waste & organics	62	60.9	3215	199300	70.8	75	2055	145516	71.6	66.4	2762	197784
	2. Mix paper	8.1	51.6	4281	34680	5.1	44.1	4945	25219	5.8	18	7254	42072
	3. Plastics	9.3	18.7	16981	157920	11.3	13.8	18004	203446	13.3	14	17962	238898
	4. Textiles	2.2	53.3	4390	9658	1.3	33.7	6233	8102	2.4	53.7	4352	10446
	5. Rubber & leather	0.8	25.8	5623	4498	0.6	7.9	6979	4187	0.5	14.4	6486	3243
	6. Wood	0.5	34.6	4999	2499	0.4	28.1	5495	2198	0.5	24	5809	2904
	7. Yard waste	11.8	77	1640	19347	4.7	61.8	2723	12799	1.2	54.9	3215	3858
	8. Fine	0.0				0.0				0.0			
		94.7			427902 Btu	**94.2**			401468 Btu	**95.3**			499205 Btu
					4279 Btu/lb				4015 Btu/lb				4992 Btu/lb
					2375 kcal/kg				**2228** kcal/kg				**2770** kcal/kg

SOURCE: Ministry of Housing and Local Government Malaysia, July, 2001.

Table 2.10(b) Calorific value of MSW(wet basis) for office and commercial areas in Kuala Lumpur

	RESIDENTIAL-HIGH					RESIDENTIAL-MEDIUM				RESIDENTIAL-LOW			
avg CV	CATEGORIES	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu	% Comp	Moisture content	Energy Btu/kg	Btu
	1. food & organics	62.0	60.90	2988	185234	70.8	75.0	1910	135246	71.6	66.4	2567	183825
	2. mix paper	8.1	51.60	3583	29024	5.1	44.1	4139	21106	5.8	18.0	6071	35211
	3. plastics	9.3	18.70	14563	135437	11.3	13.8	15441	174482	13.3	14.0	15405	204887
	4. textiles	2.2	53.30	4106	9033	1.3	33.7	5829	7578	2.4	53.7	4071	9770
	5. rubber & leather	0.8	25.80	6027	4821	0.6	7.9	7480	4488	0.5	14.4	6952	3476
	6. wood	0.5	34.60	4854	2427	0.4	28.1	5337	2135	0.5	24.0	5641	2821
	7. yard waste	11.8	77.00	1592	18782	4.7	61.8	2644	12425	1.2	54.9	3121	3745
	8. fine	0.0				0.0				0.0			
		94.7			384759 Btu 3848 Btu/lb 2135 kcal/kg	94.2			357461 Btu 3575 Btu/lb 1984 kcal/kg	95.3			443735 Btu 4437 Btu/lb 2462 kcal/kg

SOURCE: Ministry of Housing and Local Government Malaysia, July, 2001.

00 kg/ m^3 *(Lardinois, 1993)*. In Kano, Nigeria, where refuse at the source averaged 250 m^3, refuse which had been deposited in heaps at communal collection points, picked er by scavengers, rested for a coupled of days, and loaded by pay-loaded onto tipper ck, exhibited a density of about 600 kg/ m^3.

5.2 Moisture content

oisture content for organic material such as vegetable (*Table 2.11*) differs greatly pending on the income.

Table: 2.11 Putrescible, and moisture content

ity /Country	Moisture Content	Vegetable/Putrescible Content
NDUSTRIAL COUNTRY		
Jew York, U.S.A, Singapore	22%	22%
MIDDLE INCOME COUNTRIES		
Kuala Lumpur	61.5%	63.7
OW-INCOME COUNTRIES		
Bandung , Indonesia	80%	75
Calcuta, India	29%	36
Lahore, Pakistan	52%	49

OURCE: Curlee, (1996)

he (mostly organic) waste generated in low-income counties has a higher moisture ontent and waste density, making it heavy and unsuitable for incineration or long-istance transport, and it contains substantial amount of dust, giving relatively small article sizes. In choosing appropriate methods of treatment, the composition and haracteristic of waste must be taken into account, as well as, factors such as population lensity, climate, access to households, traffic conditions and land availability *(Cointreau, 1982)*.

Wastes from urban areas in developing countries is somewhat dependent on mate, especially in places where waste is stored on open ground while awaiting for llection. Waste from urban areas in developing countries have a much higher percentage food waste in their overall refuse mix. They apparently have correspondingly higher oisture content. In general, moisture content of 50 to 60% is considered optimum for mposting. The average moisture content for European refuse is higher than average oisture content for refuses in the United States. The heat content, or the caloric content the European refuse is considerably lower than that generated in the United States, incipally because of relatively lower percentages of paper and plastics in the European fuse.

.5.3 Waste composition

The waste composition varies with factors such as housing type, socio-economical evel, seasons and etc. Rapid urban population growth had led to an increase in number of eople living on each unit of urban land. More and more people are coming to city because f the attractions of the city for employment and better quality of life. Faster than ever efore, the human world is becoming an urban world. Near the end of this decade, a lemographic milestone will be passed: for the first time in the history of the urban opulation will exceed than in the urban habitat. Urbanization and the increase in opulation have brought in many changes in the quality of solid waste composition. The quantity and composition of MSW in urban areas provide a mirror of the society that eflects the affluence of the society, their way of life, their economic status and their social navior. In developed countries,. the generation of organic municipal waste is lower mpared to low and middle-income countries. In industrialized countries some 6-30% of urban waste is organic, compared with about 40-85% in low-income countries. Table 12 depicts the components in residential MSW for low income, middle-income and per income states in Malaysia (excluding recycled materials).

In Malaysia, the organic vegetable waste was the highest in most council. Paper as the second largest waste component in all Malaysian towns. The component of solid aste stream varies within the urban centers. This provides a mirror of the society that flects among the culture, rising quality of life, and high rates of resource consumption atterns. The composition and parameter of municipal solid waste generated in Kuala umpur (most industrialized and populated in Malaysia) is shown in Table 2.13. The ercentage and the composition (wet basis) of solid waste and dry basis in Kuala Lumpur re shown in Table 2.14(a) and 2.14(b). The tables show that the majority components of ISW are combustible waste. The more urbanized, industrial and affluent the community s, the more complex and increased volume of solid waste.

Accra, Ghana's capital city (population 1.4 million), generates approximately 750-300 tonnes of solid waste per day (tpd), a per capita generation rate between 0.5-0.6 kg/day (*Warmer Bulletin, 1999*). A study by Accra city's waste management department n 1994 revealed MSW composition and generation rates for various residential areas in Accra (see Table 2.15). The main sources of solid waste are residential, commercial (market, shops, restaurants and hotels), industrial, and institutional (hospitals and schools). Restaurants and markets in the city generated 60,000 cubic meters (m^3) of organic solid waste each year. By weight, domestic solid waste constitutes 85% of the city's municipal

Table: 2.12 Typical distribution of components in residential MSW for Low-Income, Middle-Income and Upper-Income states (excluding recycled materials) in Malaysia

Component	Low-income states %	Middle-income states %	Upper-income states %
Organic			
Food wastes	40-85	20-65	6-30
Paper	1-10	8-30	20-45
Cardboard			
Plastic	1-5	2-6	2-8
Textiles	1-5	2-10	2-6
Rubber	1-5	1-4	0-2
Leather			0-2
Yard wastes			10-20
Wood	1-5	1-10	1-4
Misc. organic			
Inorganic			
Glass	1-10	1-10	4-12
Tin cans			2-8
Aluminum	1-5	1-5	0-1
Other metals			1-4
Dirt, ash, etc.	1-40	1-30	0-10

SOURCE: Ministry of Housing and Local Government, July 2000.

Table 2.13 The composition and parameter of MSW in Kuala Lumpur

	PROXIMATE ANALISIS PARAMETER (AVERAGE VALUE)- WET BASIS															
	SOURCE	RESIDENTIAL High Income					RESIDENTIAL Medium Income					RESIDENTIAL Low Income				
	Constituent	% C	M	VM	FC	ASH	% C	M	VM	FC	ASH	% C	M	VM	FC	ASH
	Combustible															
1	Food waste & organic	62.0	62.5	22.0	9.7	5.8	70.8	76.0	17.3	4.1	2.6	71.6	66.4	22.6	5.8	5.2
2	Mix paper	8.1	49.7	38.7	7.2	4.4	5.1	46.9	40.2	8.3	4.6	5.8	18.0	60.6	12.2	9.2
3	Mix plastics	9.3	16.5	82.7	0.2	0.6	11.3	14.6	79.6	3.7	2.1	13.3	14.0	77.7	2.5	5.8
4	Textiles	2.2	48.4	43.1	7.8	0.7	1.3	37.9	49.2	11.0	1.9	2.4	53.7	36.7	7.9	1.7
5	Rubber & leather	0.8	23.3	57.1	11.3	8.3	0.6	9.6	60.9	9.8	19.7	0.5	14.4	62.7	9.1	13.8
6	Wood	0.5	32.3	43.7	23.2	0.8	0.4	28.5	52.8	14.6	4.1	0.5	24.0	58.2	16.0	1.8
7	Yard waste	11.8	73.0	19.2	5.2	2.6	4.7	64.0	26.1	7.3	2.6	1.2	54.9	33.5	8.9	2.7
8	Fine	0.6	44.1	18.8	5.5	31.6	0.7	51.5	21.8	5.8	20.9	0.5	55.1	16.9	4.7	23.3
	AVERAGE	95.3	54.6	28.5	7.6	4.6	94.9	61.9	25.9	4.4	2.7	95.8	52.9	32.0	5.6	5.3

% C -Percent composition; M - Moisture content; VM - Volatile mater; FC - Fixed carbon

	SOURCE OF WASTE	COMMERCIAL SHOPHOUSE					COMMERCIAL HAWKER CENTRE					INSTITUTIONAL OFFICE WASTE				
	Constituent	% C	M	VM	FC	ASH	% C	M	VM	FC	ASH	% C	M	VM	FC	ASH
	Combustible															
1	Food waste & organic	71.7	73.7	17.3	3.9	5.1	79.9	73.1	19.0	4.1	3.8	58.7	75.0	14.5	3.9	6.6
2	Mix paper	4.7	57.7	33.2	6.5	2.6	4.4	58.8	28.5	8.8	3.9	7.9	55.1	34.5	7.1	3.3
3	Mix plastics	9.2	15.1	78.8	1.1	5.0	11.9	57.5	35.9	5.9	0.7	16.1	23.4	68.3	6.7	1.6
4	Textiles	1.8	53.2	38.4	6.8	1.6	0.0	0.0	0.0	0.0	0.0	0.8	50.5	40.5	7.5	1.5
5	Rubber & leather	1.9	15.4	61.7	5.1	17.8	0.0	0.0	0.0	0.0	0.0	0.2	14.3	51.9	10.8	23.0
6	Wood	5.8	29.5	52.9	12.9	4.7	0.0	0.0	0.0	0.0	0.0	0.2	31.7	46.5	16.5	5.3
7	Yard waste	0.7	88.9	8.2	1.9	1.0	0.0	0.0	0.0	0.0	0.0	9.7	72.2	19.8	5.4	2.6
8	Fine	0.0	0.0	0.0	0.0	0.0	0.3	71.8	18.9	5.1	4.2	0.5	58.3	19.6	5.5	16.6
	AVERAGE	95.8	60.5	26.2	4.2	4.9	96.5	68.1	20.8	4.4	3.3	94.1	59.9	24.8	4.6	4.8

% C -Percent composition; M - Moisture content; VM - Volatile mater; FC - Fixed carbon

SOURCE: Ministry of Housing and Local Government Malaysia, July, 2001.

Table: 2.14(a) The percentage and composition(wet basis) of solid waste in Kuala Lumpur

	% Waste Composition-Wet Basis					
	SOURCE OF WASTE	RESIDENTIAL HIGH INCOME	RESIDENTIAL MEDIUM INCOME	RESIDENTIAL LOW INCOME	COMMERCIAL	INSTITUTIONAL OFFICE WASTE
	Combustible					
1	Food waste and organic	62.0	70.8	71.6	79.0	58.7
2	Mix paper	8.1	5.1	5.8	5.1	7.9
3	Mix plastics	9.3	11.3	13.3	9.1	16.1
4	Textiles	2.2	1.3	2.4	0.7	0.8
5	Rubber and leather	0.8	0.6	0.5	0.7	0.2
6	Wood	0.5	0.4	0.5	1.9	0.2
7	Other combustibles	0.0	0.0	0.0	0.0	0.0
8	Yard waste	11.8	4.7	1.2	0.2	9.7
9	Fine	0.6	0.7	0.5	0.1	0.5
	Sub total	95.1	94.7	95.8	96.7	94.1
	Incombustible					
10	Glass	1.6	1.2	2.1	1.2	1.1
11	Ferrous	2.8	2.4	1.9	1.6	4.8
12	Aluminum	0.1	0.1	0.1	0.1	0.1
13	nonferrous	0.0	0.0	0.0	0.0	0.0
14	other onorganics	0.0	0.0	0.0	0.0	0.0
15	OBW	0.6	1.7	0.5	0.0	0.0
	Sub total	0.5	5.3	4.5	2.9	6.0
16	***Bulky density***	273.1	310.7	278.8	372.1	277.1
17	***Moisture Content***	56.8	67.0	56.4	74.4	64.2

SOURCE: Ministry of Housing and Local Government Malaysia, July 2001.

Table: 2.14(b) The percentage and composition (dry basis) of solid waste in Kuala Lumpur

	% Waste Composition-Dry Basis					
	SOURCE OF WASTE	RESIDENTIAL HIGH INCOME	RESIDENTIAL MEDIUM INCOME	RESIDENTIAL LOW INCOME	COMMERCIAL	INSTITUTIONAL OFFICE WASTE
	Combustible					
1	Food waste and organic	51.3	45.7	50.4	60.0	36.6
2	Mix paper	9.1	7.1	10.3	8.3	8.9
3	Mix plastics	16.9	24.4	24.3	17.5	30.7
4	Textiles	2.5	2.1	2.3	0.9	1.0
5	Rubber and leather	1.2	1.4	0.9	1.5	0.4
6	Wood	0.7	0.7	0.8	4.3	0.3
7	Other combustibles	0.0	0.0	0.0	0.0	0.0
8	Yard waste	6.8	3.8	1.1	0.1	6.7
9	Fine	0.8	1.1	0.5	0.1	0.5
	Sub total	89.3	86.3	90.6	92.7	85.1
	Incombustible					
10	Glass	3.4	3.3	4.4	3.2	2.8
11	Ferrous	6.1	6.4	4.0	4.2	11.8
12	Aluminum	0.0	0.2	0.1	0.1	0.3
13	nonferrous	0.0	0.0	0.0	0.0	0.0
14	other onorganics	0.0	0.0	0.0	0.0	0.0
15	OBW	1.2	3.8	1.0	0.0	0.0
	Sub total	10.9	13.7	9.5	7.5	14.9
16	***Bulky density***	273.1	310.7	278.8	372.1	277.1
17	***Moisture Content***	56.8	67.0	56.4	74.4	64.2

SOURCE: Ministry of Housing and Local Government Malaysia, July 2001.

olid waste stream; remaining 15. % is accounted for by commercial, institutional and nstitutional sectors. The composition of waste (Table 2.15) is also closely related to verall economic levels of the population from which it originates.

Table 2.15: Waste generation and composition in different socio-economic areas of Accra, Ghana.

	Low income areas	**Medium income areas**	**High income areas**	**Accra**
Population (millions)	1.055	0.325	0.042	1.412
Waste per capita (kg/person/day)	0.40	0.60-0.76	0.62	0.47
Waste density (kg/liter)	0.50	0.24	0.21	0.43
Waste Fraction	**Waste composition (per cent by weight)**			
Organic	49.1	73.0	72.6	55..3
Inert	41.2	12.1	8.9	33..5
Plastics	2.7	3.0	4.0	2.8
Glass	0.4	1.2	2.0	0.6
paper	3.5	6.0	7.2	4.2
Metals	0.7	1.7	2.8	1.0
Textiles	2.1	2.4	1.5	2.2
Others	0.3	0.6	0.9	0.4
Total	100.0	100.0	100.0	100.0
Compostable (per cent)	90	80-90	80	89
Recyclable	8	8-17	16	9
Quantity (tonnes /day)	412.3	220.8	26..3	659.4
Quantity (per cent of total)	62..5	66..5	4.0	100.0

SOURCE: Warmer Bulletin 69, 1999

The characteristic of MSW changes with time as the society evolves to the needs of development. The quantity and composition of waste of the generated solid waste in different areas in Spain provide the mirror of different economic level of the population. Table 2.16 shows that the composition of municipal waste stream varies in different areas in Spain.

Table 2.16: Municipal waste stream in different areas in Spain (wet basis)

Composition	Urban (% weight)	Semi-urban (% weight)	Rural (% weight)
Organic	45	45	50
Metal	4	4	4
Glass	7	6	5
Plastic	8	8	9
Paper and Board	25	23	20
Others	11	14	12
Total	100	100	100

SOURCE: Warmer Bulletin 64, 1999

In recent years, the proportion of glass has declined while solid waste paper and plastic packaging materials) has increased. Increased usage of pre-processed; rozen and packaged foods has caused the amount of food waste, paper and plastic ontainer waste to increase. The amount of kitchen waste disposed increased as the opulation increased. The higher-income groups produce higher amounts of easily etrievable and valuable items such as paper, metals and plastics. In Guadalajara Metropolitan Zone (GTZ), Mexico, the amount of paper accounted 10.6 per cent by weight, plastic 9.2 per cent, glass 4.0 per cent, and total 1.5 per cent. Only 20 per cent of he MSW collected in Tucson, Arizona was food waste compared to 41 per cent for GMZ. This was due to the greater use of unprocessed foods in developing economies, which esulted in the generation of large amounts of waste during preparation. In Israel, during he past twenty years, the composition of Israel's domestic solid waste has changed dramatically (see Table 2.17). For example, while organic waste continue to be the largest omponent of the household waste in terms of weight; its share has declined from 65% to 8%. During the same period, the percentage of paper has increased by about 30% (from 7% to 22%)

hile plastic doubled(from 7 to 14%). Plastic and paper alone take up nearly two-thirds of e volume of Israel's MSW.

Table 2.17: Waste composition in Israel (1997)

Waste Fraction	proportion(%)
Organic food waste	45.3
Paper and Board	19.4
Plastic	13.1
Glass	3.0
Metal	5.4
Yard waste	3.0
textile	5.0
Others	14
Total	100

SOURCE: Warmer Bulletin 65, 1999.

he composition of municipal solid waste in various parts of the world is shown in Table .18. Plastic waste contributes to about 9% in terms of weight and 24% in terms of olume of the U.S.A municipal waste stream (*Curlee, 1993*). Of the 19.8 million tonnes of ost-consumer plastic waste that entered the municipal waste stream in 1994, 5.6 million onnes (28%) came from durable goods and, 4.8 million tonnes (24%) was from ondurable goods. From a resin perspective, HDPE (19.7%) and LDPE (28.7%) constitute early half of all plastic in the municipal waste stream. Compositional differences are ccountable to economic and cultural differences of the population and, climatic and eographic differences among cities. An important difference between the urban waste enerated by low-income and industrialized countries is the percentage of the organic aterial. The character of refuse in all of European countries appears to be undergoing significant change. In general, the percentage of material of organic character is considerably higher in the European refuse; the relative amount of organic material appears to decrease with the relative industrial growth of any given country. In a similar way, the paper content of European refuse is not as high as the paper content of American refuse, but in highly industrialized countries of Western Europe, the paper content is

Table 2.18: The composition of MSW(%) in various parts of the world

Countries	Accra #	New Zealand @	EEC *	USA *	Asia (Urban) *	Middle East (urban) *	Belgium ®	UK [a]
Year	1994	1995	1997	1997	1997	1997	1977	1995
Organic	55.3	36	-	-	-	-	30-50	20.2
Inert	33.5	-	-	-	-	-	-	-
Plastics	2.8	7	4.6	5.0	1.0	1.0	-	11.2
Glass	0.6	2	8.3	9.0	0.2	5.0	5-10	9.3
Paper	4.2	19	28.7	43.0	2.0	16.0	10-30	-
Metals	1.0	6	6.0	9.5	0.1	5.0	3-5	7.3
Textiles	2.2		3.1	1.5	3.0	3.0	-	2.1
Potentially hazardous	-	8	-	-	-	-	-	-
Cotton fabric	-	-	-	-	-	-	-	-
Construction materials	-	-	-	-	-	-	-	-
Leather	-	-	-	-	-	-	-	-
fine waste	-	-	-	-	-	-	-	-
Putrescribles		-	25.4	12.0	75.0	50	-	-
Others	-	5	23.9	25.5	21.7	23.0	5-30	16.7
Total	100	100	100	100	100	100	100	100

SOURCE: Warmer Bulletin 73, 1999
@ *SOURCE*: Warmer Bulletin 77, 2001
* *SOURCE*: Agamuthu , 1997
® *SOURCE*: Fontana., 1977
[a] Journal of Education in Chemistry, 1997.

gher than in those countries which are dependent upon agriculture as a basis for the tional economy. The materials generated in municipal solid waste in United Kingdom, is pidly increasing because of increased use of plastics in water and wine bottles. Plastics astes are increasing rapidly in Italy, but the use of plastic bottles for wine is forbidden by w in that country. Other plastic packaging seems to account for the increasing pearance of plastic in the solid waste stream. There is a considerably greater amount of ist and fine-sized materials in municipal solid waste in European.

Some 44 percent of residential solid waste by weight in Shanghai is broadly efined as organic; the balance is inorganic. Organic wastes include paper products, wood, oths and food remains. The inorganic portion comprises plastic, glass, brick, porcelain, al ash, metal, and miscellaneous products. During the mid-1980s, the percentages of od waste and residential use of coal decreased, but the percentages for all other sources se. This probably relates to increase in industrialization, widened availability of onsumer goods, and more disposable income. An increased percentage of China's sidential waste includes toxic materials such as household cleaners, detergents, esticides, paints, thinners, and solvents *(Andrews 1987; Conn 1989)*. The amount of rganic waste disposal increased when the population increased.

.5.4 Sosio-economic survey analysis

A survey by Davidson (1988) of low-income residential areas in Cincinnati, hio, indicated that the amount of solid waste generated per day per capita was much igher than the average generation rates for the state. The apartment dwellers produced bout half the quantity of waste that a single-family dweller generated. His studies also ore willing to redeem beverage·containers such as glass, bottles, aluminum cans and ine bottles than men (*Chung, 1996*).

Packaging had become a "point of sales" as well as performing a utility function *'warup, 1992)*. The term 'packaging' is normally used for all materials necessary to ansport and distribute goods within the production cycle, and to the final consumer. hese materials have several functions schematically described as protection, transport and arketing of products and final consumer goods *(Alberto, 1994)*. The rise in the onsumption of packaging materials developed with spreading of 'disposal products' and e growth or the distribution industry. Plastic packaging seems to account for the icreasing appearance of plastic in the solid waste stream.

.6 Waste management

Management is the process of achieving organizational goals by engaging four ajor functions of planning, organizing, leading and controlling (*Beale,1980*). This efinition recognizes that management is an ongoing activity, entails reaching important oals, and involves knowing how to perform the major functions of management. In its cope, solid waste management includes all administrative, financial, legal, planning and ngineering functions involved in the whole spectrum of solutions to problems of solid vaste.

Solid waste management can be defined as the judicious use of a means to achieve *n end.* "An end" is the removal of the rejected from the material flow pattern. Solid vaste management is defined as a complex dimension covers the control of generation, torage, collection, transfer and transport, processing and finally disposing of the waste in ıanner that is in accord with the best principles of public health, economics, sociology, mography, engineering, conservation, aesthetic, and environmental consideration. *gure 2.1* shows the functional elements and productive outputs of a municipal solid ıste management system. The management of solid waste was major environmental ue in the 1980's. The concern over waste management and disposal parallels an creased appreciation of the concept of people as the custodians of the environment with ıste production being increasingly regarded as an antisocial activity rather than as the cessary and inevitable consequence of the demands of a consumer society. Waste anagement is a complex business calling for wealth of knowledge and involving erplay of scientific, technological, marketing and administrative skills. It is an industry its own right *(Snow, 1988)*.

There are a number of different operations associated with a solid waste anagement system. Each operation accomplishes a specific purpose in the chain of tions required to manage the solid waste satisfactorily. Understanding each of these eps is necessary in order to develop an efficient management system. There are various ays of arranging the pick of refuse from premises and transferring it to the collection ehicle. Some are more costly than others, some are hygienic, some less arduous for ollectors, and some require mechanical aids. Front curbside collection of waste is the ost widely practiced.

In many countries waste is collected at the point of waste generation; at designated ickup points; from refuse collection vehicles; at interim transfer stations or waste-rocessing facilities; and at the ultimate disposal site, either by municipality or by informal

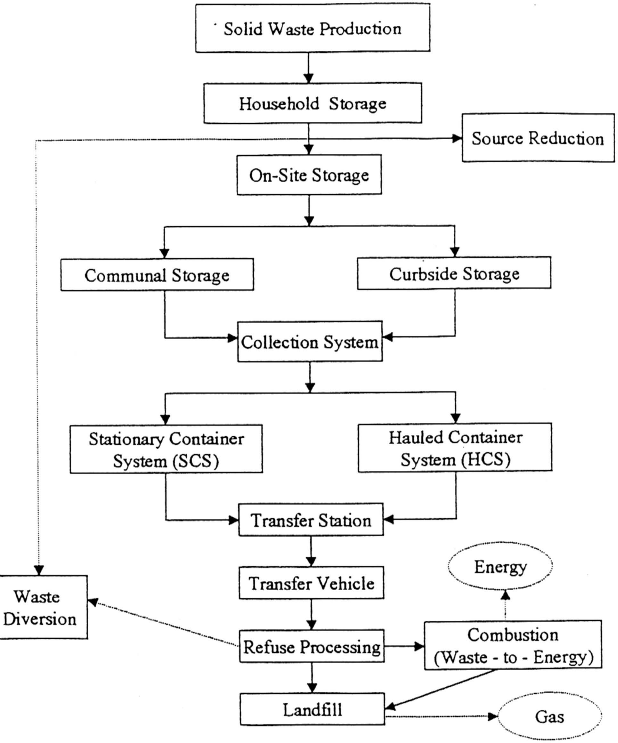


Figure 2.1 : Functional elements and productive output of a Municipal Solid Waste Management System.

SOURCE: **Douglas, 1998**

:avengers Informal solid waste management systems are usually complex, consisting of :veral strongly interrelated activities. Micro-enterprises, dealers or middlemen, pickers at ıe dump site, as well as municipal workers and itinerant scavengers, all play ıdispensable roles in the collection, treatment and disposal of waste.

In Manila (Philippines), about 20,000 scavengers live around a dumpsite known as Smokey Mountain". In Bangkok (Thailand), about 1000 scavengers participate in the ollection and recycling of municipal waste. In Cairo (Egypt), nearly 4,000 scavengers nown as wahis and zabbaleen, haul over 50% of collected municipal waste with their onkey carts. In Ciudad Juarez (Mexico), " landfill scavengers were organized into a :cycling cooperative which obtained a concession arrangement to operate the city's ındfill;" *(Coolidge, 1993)*. In Medellin (Colombia) scavengers were organized into small firms for collecting commercial wastes and for purchasing recyclable materials oor-to door''.

Almost all-inorganic waste in India was carried out through the efforts of the ıformal sector (rag pickers, waste traders, shanty recyclers and factory owners) across the ountry. The work of rag pickers was estimated to be responsible for managing 12-15 per ent of the total MSW produced in urban India. It has been calculated that, in Delhi, round 100,000-150,000 rag pickers rummage daily through the waste heaps. The ıformal sectors have proved useful for the municipality. Their involvement in municipal olid waste management have partially emptied the overflowing bins by processing the rganic waste(*Warmer Bulletin, 1999*).

In Switzerland, 1986, the Federal Commission on Waste Management had borated national "Guidelines for Waste management". The guidelines cover scientific, hnical and economic as well as political principles and contain suggestions as to how to oly these principles in practice. According to the guidelines, waste has to be managed marily so that protection of man and the environment is ensured. As an entity, systems handled waste have to be compatible with the environment.

There is evidence that government agencies can provide solid waste service iciently. For example, the Shanghai (China) municipal government runs a profitable work of recovery stations and waste utilization plants. Private participation through ntracting, franchising, competitive bidding, and equipment leasing had reduce the cost managing municipal waste.

In Bangkok (Thailand), contracted MSW management service appears to have vered the cost. In Seoul (Korea), Jakarta (Indonesia), and Bogota (Colombia), private lection commands a substantial cost advantage in labor, wages, and benefits.

There are laws to regulate waste management in Kuala Lumpur. Some of these : -

Local government Act, 1976,

Street, drainage and Building Act, 1974,

. Refuse collection, removal and disposal (Federal Territory), 1981,

. Parks (Federal Territory) By-laws, 1981,

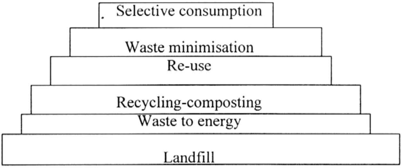
Hawkers (Federal Territory) By-laws, 1979,

. City of Kuala Lumpur (Earthworks), By-law, 1975,

I. The Federal Territory (Planning) Act, 1982. (Sham, S. 1988).

n Kuala Lumpur, under the privatization scheme, private firms make more trips per ehicle per day and collect more waste on each trip, and hence are nearly 50% more oductive than the public service. Evidence from Latin American cities also points to wer costs and higher productivity for the private sector *(Coolidge, 1993)*.

In the United Kingdom, to counter the growing waste disposal problem, the vernment developed a waste diversion hierarchy *(Baetz, 1993)*. The waste hierarchy was itially introduced by the EU 4th Action Programme on the Environment (1987) and was corded greater emphasis in the EU 5th Action Programme. It represents the government's licy for achieving sustainable waste management. The sustainable waste management d been described as having regard for the future environmental and economic nsequences of today's waste management decisions. It includes taking account of the ll environmental cost (in addition to the economic cost) of products and policies. The erarchy is typically composed of (1) waste reduction, (2) by-product reuse and (3) by-oduct recycling components. The waste hierarchy provides a framework ithin which local, regional and national waste management decisions can be taken by cal authorities when considering management strategies for municipal solid waste anagement, treatment and disposal. The aim of the government is to guide waste policy akers requiring the movement of waste practices from the bottom of the hierarchy isposal dominated) through the middle (treatment practices) to the waste avoidance *(Red al, 1998)*. In other words, the waste minimization, reuse and recovery become more tractive management options for waste producers and local authorities who are obliged manage these waste in future *(Figure 2.2)*.



SOURCE : Geography (1998)

Figure 2.2 The waste Management Hierarchy

The first component, waste reduction, is being addressed primarily through oduction/packaging redesign, change in consumer purchasing, and proposed packaging gulations. By-product recycling has recently experienced a surge in interest in developed untries and will continue to grow as the markets developed.

The municipalities across US have implemented unit pricing of residential solid aste, or pay- as- you-throw programs. It's an innovative approach to encourage gnificant waste reduction and diversion. Instead of paying a monthly or annual flat fee, a usehold pays per unit of waste generated under a unit pricing program.

In Australia, the government had taken on a more informal and environmental endly approach. This is because Australia has one of the largest rates of domestic solid aste production in the world. All levels of Australian local government have identified s problem and as a result now advocate, " The Australian Waste Management erarchy" as stated below;

a. waste avoidance
b. waste reduction

c. waste reuse

d. waste recycling

e. waste disposed

is hierarchy puts the emphasizes on waste avoidance in the hope that this will unteract the copious amount of waste being produced by a throwaway *society* *tp.//w.w.w.aljian.com.au/stefann/summary.htm)*

Currently there is a widespread interest among local governments to incorporate ınicipal solid waste composting into their integrated solid waste management systems. United States and Europe, municipal solid waste composting is an alternative to the sposal of significant components of the waste stream in sanitary landfills. A recent rvey of municipal solid waste composting in the US lists 15 facilities that are currently erational, and an additional 23 that are somewhere in the planning, design, permitting or nstruction stage. In Europe, facilities are operational or under construction in France, olland, Switzerland, Italy, Greece and Spain. The growing interest in MSW composting s been stimulated by a desire to minimize the amount of garbage entering landfills. The mber of yard waste composting facilities throughout the US had grown tremendously er the past 5 years, in large part because state regulations have increasingly banned yard mmings from landfills *(Renkow, 1998).*

Wastes should in general be treated within national boundaries and according to gional viewpoints. The Swiss objectives for waste management are to produce materials : short-and long terms reuse, and to produce materials with "final storage quality" which ıen disposed have in the environment yield sustainable material fluxes only *(Brunner, 92)*. The Danish government had put tight restrictions on waste management, giving gional municipalities the control of waste collection and the operation of landfill. Under nish law, no regulation is put on the pricing system (waste collection price) that the thorities use. Frequently these municipalities use-pricing systems based on the volume waste produced rather than on its weight. On 1 January 1987, a waste tax was put into ect in Denmark, which imposed charges on the disposal (dumping/ land filling and cineration) of non-hazardous waste according to weight. It is a fiscal environmental tax venue from this tax can be used to finance deficits or shift taxes from labor to resource) ose purpose is to reduce waste generation and to increase recycling and the reuse of usehold, industrial and collection services.

In the United States, the Environmental Protection Agency is actively promoting e use of landfill methane gas through its Landfill Methane Outreach Programme. It monstrates to companies, utilities and communities, how to capture landfill gas and tract its energy content. So far over 150 landfills in the United States use landfill ethane to generate electricity as well as fuel boilers in schools, commercial and industrial cilities *(Solid Waste Management Glossary. 1972).*

Solid waste management planning models and methods are used to analyze rformance and cost of alternative waste management strategies. They address the llowing aspects of solid waste management: waste generation, separation of waste mponents at their source, storage and collection of wastes, transport of waste from llection areas to intermediate processing systems, transport of waste to landfills, waste sposal at landfills and multiple simultaneous recycling, composting, and resource covering *(Wilson, 1981).*

Applications of microcomputer software in municipal solid waste management r developing countries have been reviewed and it is suggested that software programs uld bring about cost-effective improvement in planning and management of solid wastes *ight, 1990)*. LAMSAC had developed a software package known as "STREETS" for anager's basic tool for decision-making. Currently 15 authorities are using the system. ne system is an interactive computer program, which is common to a whole range of petitive service. The uses of STREETS enable authorities to attain substantial financial nefit and computerized control over a considerable range of manual service *(Roelofs, 96)*.

Several modeling approaches such as linear programming techniques to optimize e location of a site with respects to haul costs; analytical framework for waste-facility ting; the combined purchase-stored model for the prediction of household hazardous iste; and heuristic techniques to locate waste disposal site had been used to determine ste disposal sites *(Roelofs, 1996)*.

The cost of solid waste disposal in developing country cities usually accounts for a y large part of municipal budgets, sometimes as high as 20-40%. Collection and nsport account for three fourths of the cost. But the range in the level of costs is mendous, from $14 to $ 113 per metric ton of refuse collection *(Cointreau, 1982)*.

In Fairbanks, Alaska, a city of 27,000 inhabitants, the cost to the community for lection and disposal of solid waste is in excess of US $1,000,000 annually. In England l Wales, the collection and disposal of household waste costs around £850 million pa *ad, 1998)*.

Disposal of waste is the act of abandoning it-to put somewhere with no intention to ove it anywhere else. If the bins were not emptied or not properly managed in a day, the rious consequences can result including: human sickness and injury, water pollution, lid pollution, air pollution, and aesthetic insult and destruction of amenity value. In ban areas in particular these unwelcome effects can contribute to a poor quality of life r all.

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In Malaysia, it is estimated that about 60% to 80% of the waste management cost ssociated with collection (including transportation) *(Sham, 1988)*. In 1999, according to atistics provided by DBKL, it cost about RM 100 million on clean up the Kuala Lumpur ity. That is about RM30 million more than last year's cost (1998). And the RM 100 illion is 10 times more than that in 1997, the year before the cleaning service was ivatized *(The Star 15/7/1999)*. Littering seems like a norm in Malaysia; many people ractice" it and few are bothered by the act. Civic-conscious people are flabbergasted. ach year, two to three thousand people in Kuala Lumpur are caught littering. They are ned RM 100on the spot. More than 16,000 notices have been issued to hawkers and shop wners and lorry drivers and about RM2.4mil worth of fines were collected from the ffences.

Collection operations are highly laborious and capital intensive. Its becoming creasingly complex because the diffuse generation patterns, increasing quantity of astes, the charges of waste characteristic, accessibility problem due to poor building youts and physical infrastructures and road congestion. Most collection services in eveloping countries include a sizable crew of unskilled laborers, equipped with shovels d rakes, baskets or bins, wheelbarrows or pushcarts, and a dump truck or a cart with a aft animal. In larger urban areas, there will often be transfer stations where household rbage from an entire neighborhood will be collected and temporarily stored awaiting ckup for final disposal in an official dumpsite. Transport costs can greatly increase sposal costs this is likely to prove a greater burden on waste disposal in the future rticularly to urban populations.

.6.1 Waste recycling

Waste recycling is a popular activity in the Western world. Recycling makes onomic sense even when a material is plentiful. Recycling glass requires less energy an making it from sand. Recycling steel is cheaper than mining ore. Recycling is where e environment and the economy meet. It's becoming an integral part of business and dustry. We could reduce waste by cutting down on the packaging that surrounds our oducts. It accounts for one-third of our trash *(Baily, 1994)*. In the majority of dustrialized countries, the manufacturing and marketing of products with disposable by-oducts are well established. These items are often very cheap and are often perceived to more convenient to use than products with reusable by-products.

Source separation of household waste has gained popularity among the general iblic in Hong Kong.

Many ingenious options for reuses containers and packaging materials are possible the home. People reuse newspaper, boxes, jugs, plastic bags, cans, and bottles for many ırposes around the house. Backyard composting of trimmings and food wastes is not a ew practice among the individual and feasible households. Where the population is very ense, as in high-rise apartment buildings, municipalities may collect compostables and mpost them along with municipal organic waste *(Roelofs, 1996).*

In 1988, the city of Jakarta, Indonesia, produced more than 21,000 m^3 of municipal lid waste daily, 25% of which was recovered by an estimated 37,000 scavengers who rned \$ 0.75-3.50 per day *(Open, 1993*). Today, at least 78 factories use recovered aterial from waste for plastics, paper, glass and metal production. The recycling rate for ass and paper are as high as 60-80%. The waste paper collected by scavengers of *emulung"* makes up to 90% of the secondary raw material in this sector.

Bottles made of polyethylene terephthalate (PET) are melted down and regenerated to a cotton fiber used in jacket insulation, pillow stuffing, and car interiors, or molded to bottles again. High-density polyethylene (HDPE) containers are reduced to tiny llets that are bought by the markers of makers of shampoo and detergent bottles.

New technologies in the mechanical separation of commingled containers have en brought to market in recent years, increasing the options and efficiencies of material covery facilities (MRFs). The biggest challenges come from separating glass, which ffers from cross-contamination with other materials, breakage, the un-marketability of ixed colors, and high quality specifications for recycled glass. The renewed interest is purred by a range of concerns: loss of landfill space, contamination of groundwater by ndfills, dwindling natural resources, and, perhaps, a growing comprehension of our matched squandering.

Limitations in landfill space and growing per capita waste output have become a ajor area of concern in Denmark. In 1980's, Denmark's per capita generation of waste as higher than many of its neighbors in Europe and projections showed that its landfill ace was quickly running out. On 1st January 1987, a waste tax was put into effect in enmark, which places on the disposal (dumping/landfilling and incineration) of non-zardous waste according to weight *(Andersen, 1998)*.

In Malaysia, majority of municipal solid waste generated is currently disposed in ndfills. Most landfills in Malaysia are situated in crude waste dumps with little planning d environmental controls. With the population growth rate of 2.2 % per annum (The ar 4/4/2001), the landfills do not have the capacity to cope with the volume of wastes nerated. Table 2.19 shows the remaining capacity of waste disposal sites in Federal rritory and Selangor.

The proper management of waste has several aspects: political, social, vironmental, economical and technical. In any city it is possible to equate the standard waste management with the overall "standard of living" enjoyed by its inhabitants. sing expectations of the environmental improvement mean that storage and disposal ilities must be appropriately designed, engineered and managed. They must also be nned for future.

Table: 2.19 Waste disposal site (Landfills) in Federal Territory and Selangor

District /Municipal Council	Location	Area(ha)	Remaining Capacity(tonnes)
Kuala Lumpur	Taman Beringin	12.0	674,000
Hulu Selangor	Serendah Kerling Hulu Yam Kalumpang	3.0 0.3 60.0 1.5	n/a n/a 35,970 8,881
Sabak Bernam	Jln Pancang Bedena	4.0	n/a
Kuala Selangor	Kg Hang Tuah	2.0	19,395
Petaling	Ayer Hitam Landfill, Puchong	60.0	14,105,748
Gombak	Kundang	39.0	890,000
Hulu Langat	Beranang	20.0	n/a
Kuala Langat	Tg Sepat Banting Sedu	1.3 7.0 6.0	n/a n/a 33,434
Sepang	Air Tenang Batu Dua	5.4 1.0	n/a n/a
Ampang Jaya	Pasir Puteh	15.0	n/a
Klang	Pandamaran	40.0	n/a
Total		299	

SOURCE: Ministry of Housing and Local Government, July, 2001.

ery city has different sets of priorities, which their waste management services must eet. Typically, these priorities are taken as standards against the efficiency and ectiveness of the service. Cointreau *(1982)* listed some of the matters, which could be dressed:

- the types of waste, which are to be included in public collection, recovery and disposal, service (e.g. household, trade, inert, industrial, night soil, street sweepings, and institutional waste),
- the level of control to be exercised by the local government on wastes not collected, recovered or disposed by the public services,
- the proportion of each waste type it is intended to collect by public service (e.g. *x%* of all household waste and *y%* of all commercial waste),
- the level of citizen participation in, and convenience of, waste collection that is expected by the collection from their dwellings),
- the environmental issues to be included in the waste management plan,
- consideration will need to be taken of social and religious customs, and
- the safety standards to be exercised to protect the waste management staff from work-related infections and industrial accidents.