

**The Islamic University of Gaza
Faculty of Engineering
Civil Engineering Department**

**Environmental Engineering
(ECIV 4324)**

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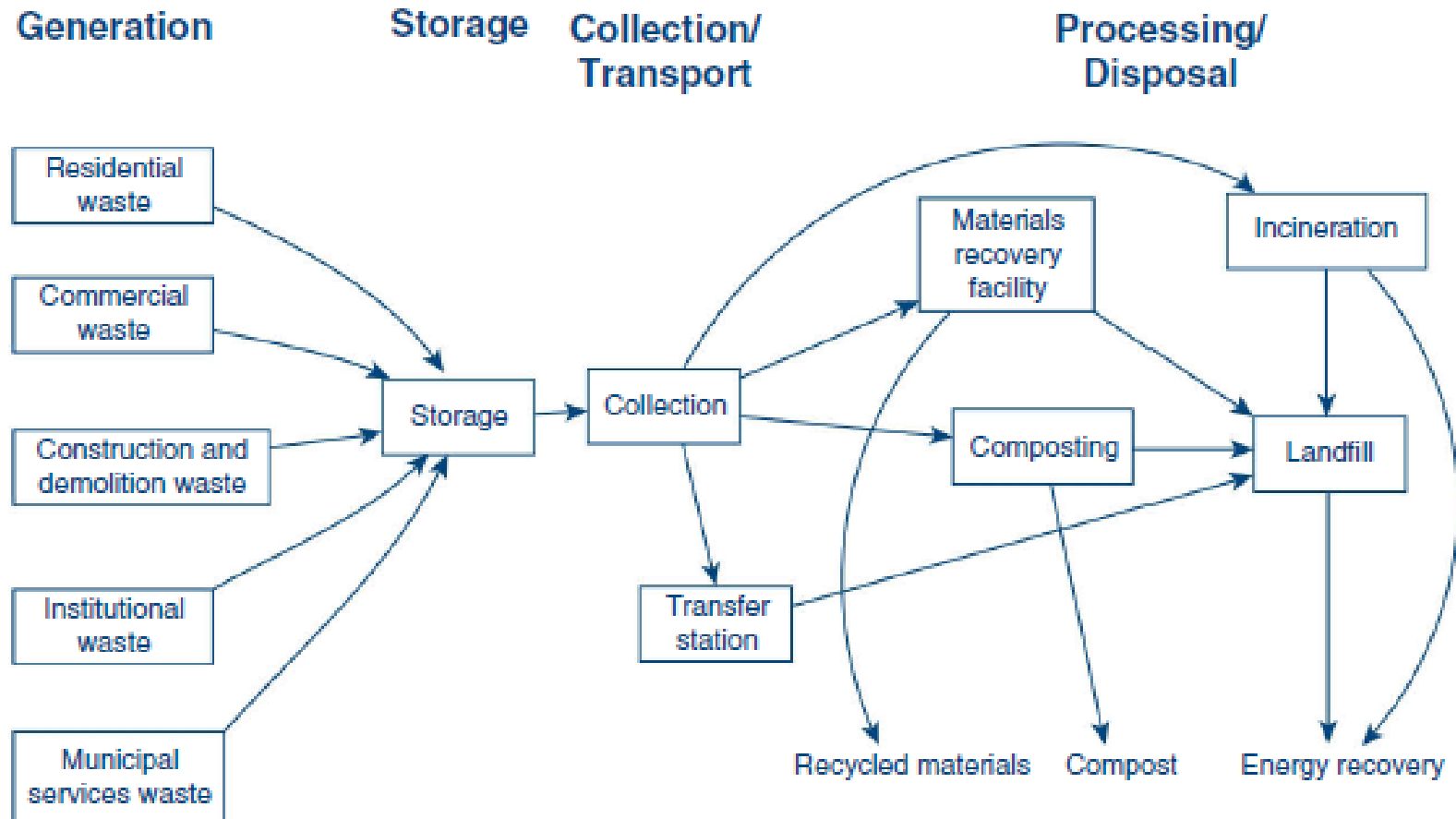
Solid-Waste Management

Introduction

Solid wastes include paper and plastic generated at home , ash produced by industry, cafeteria food wastes, leaves and cut grass from parks, hospital medical wastes, and demolition debris from a construction site. These materials are considered a waste when owners and society believe they no longer have value

Introduction

Solid-waste management varies greatly between cultures and countries and has evolved over time



Introduction

Proper management of solid waste s has five main objectives:

- 1. Follow the pollution prevention hierarchy , which prefers source reduction and recycling over treatment and disposal .**
- 2. Protect public health.**
- 3. Protect the environment (including biodiversity) and view the waste material as a resource.**

Introduction

Proper management of solid waste s has five main objectives:

- 4. Address social concerns (equity , environmental justice, aesthetics, risk, public preferences, recycling, renewable energy).**
- 5. Minimize economic, social, and environmental costs.**

Solid-Waste Characterization

SOURCES OF SOLID WASTE

Table / 10.1

Sources of Solid Waste and Typical Percentage That Makes Up Municipal Solid Waste

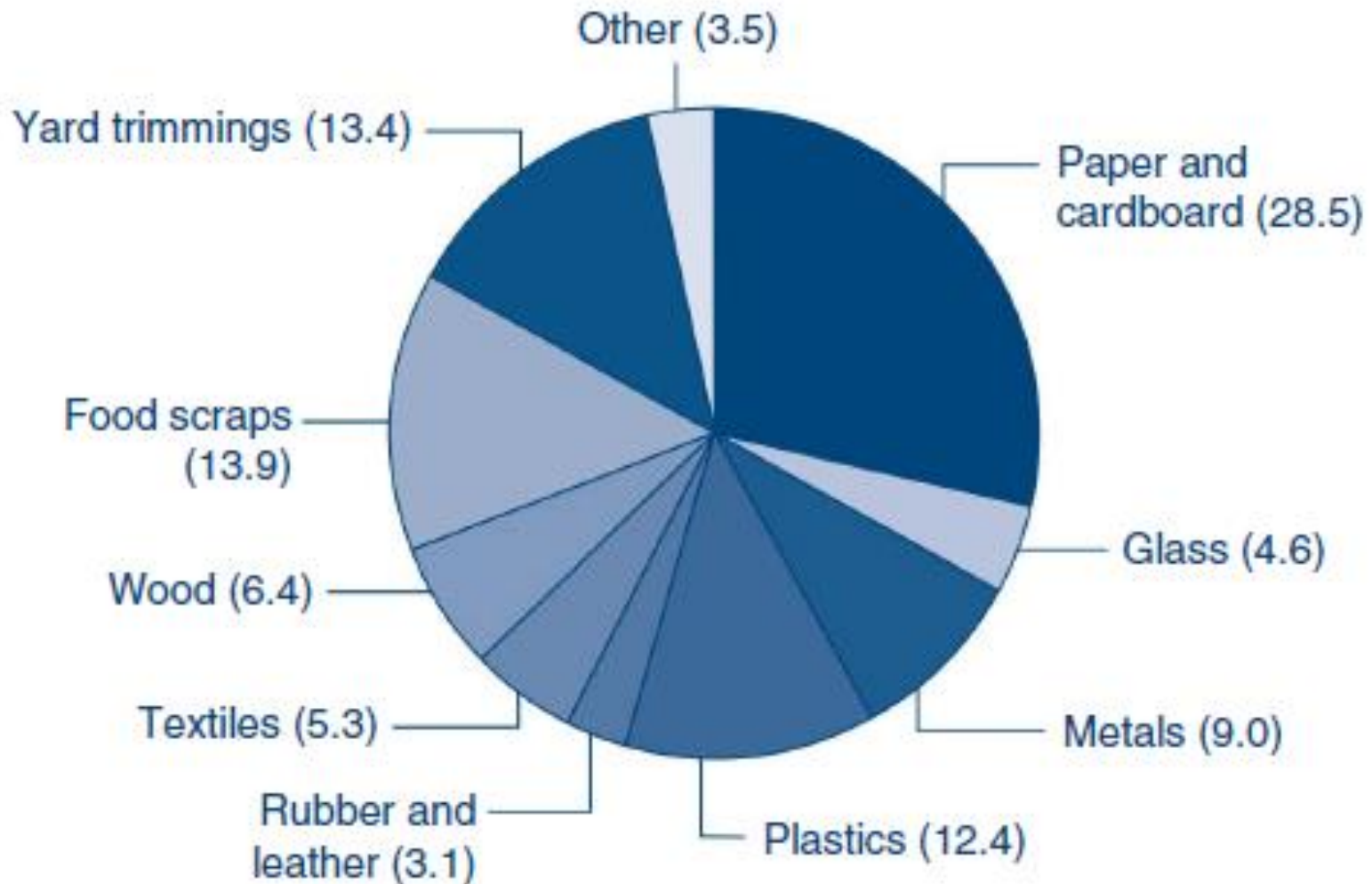
Source	Examples	Comments	Typical Percentage of MSW
Residential	Detached homes, apartments	Food wastes, yard/garden wastes, paper, plastic, glass, metal, household hazardous wastes.	30–50%
Commercial	Stores, restaurants, office buildings, motels, auto repair shops, small businesses	Same as above, but more variable from source to source. Small quantities of specific hazardous wastes.	30–50%
Institutional	Schools, hospitals, prisons, military bases, nursing homes	Same as above; variable composition between sources.	2–5%
Construction and demolition	Building construction or demolition sites, road construction sites	Concrete, metal, wood, asphalt, wallboard, and dirt predominate. Some hazardous wastes possible.	5–20%
Municipal services	Cleaning of streets, parks, and beaches; water and wastewater treatment grit and biosolids; leaf collection; disposal of abandoned cars and dead animals	Waste sources vary among municipalities.	1–10%

Solid-Waste Characterization

SOURCES OF SOLID WASTE

Industrial	Light and heavy manufacturing, large food-processing plants, power plants, chemical plants	Can produce large quantities of relatively homogeneous wastes. Can include ashes, sands, paper mill sludge, fruit pits, tank sludge.	Not MSW
Agricultural	Cropping farms, dairies, feedlots, orchards	Spoiled food wastes, manures, unused plant matter (e.g., straw), hazardous chemicals.	Not MSW
Mining	Coal mining, uranium mining, metal mining, oil/gas exploration	Can produce vast amounts of solid waste needing specialized management.	Not MSW

QUANTITIES OF MUNICIPAL SOLID WASTE



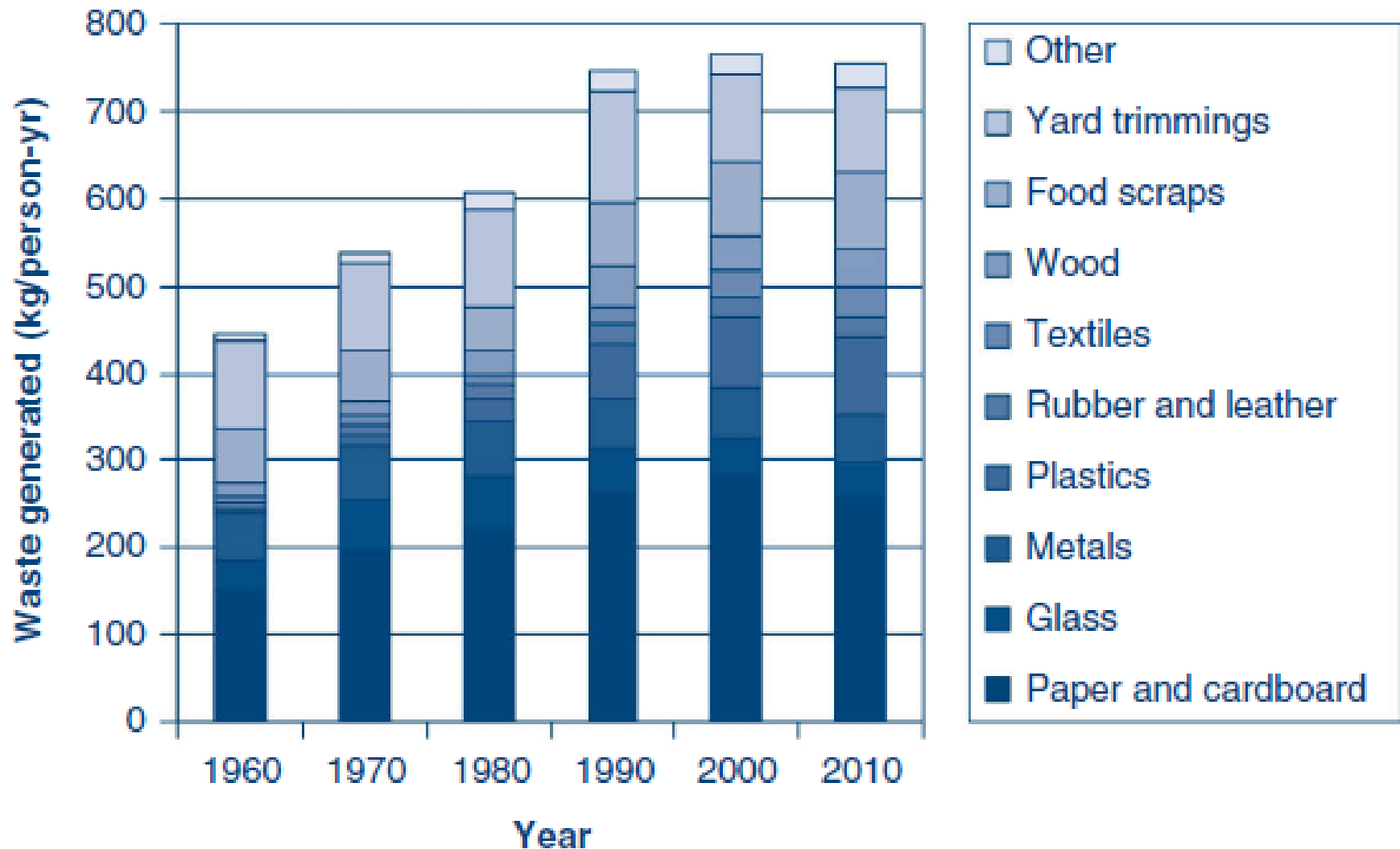
QUANTITIES OF MUNICIPAL SOLID WASTE

Table / 10.2

Quantities of Municipal Solid Waste in the United States over Time

	Mg per Person per Year ¹					
	1960	1970	1980	1990	2000	2010
Generation	0.44	0.54	0.61	0.76	0.78	0.74
Recycling	0.03	0.04	0.06	0.11	0.17	0.19
Composting	Negligible	Negligible	Negligible	0.01	0.05	0.06
Incineration	0.00	0.00	0.01	0.11	0.11	0.09
Landfill ²	0.42	0.50	0.54	0.53	0.45	0.40

QUANTITIES OF MUNICIPAL SOLID WASTE



QUANTITIES OF MUNICIPAL SOLID WASTE

Table / 10.3

Solid-Waste Composition for Five Cities of the World

Location	Food Waste	Paper	Metals	Glass	Plastic, Rubber, Leather	Textiles	Ceramics, Dust, Ash, Stones	Generation (Mg/person-year)
Bangalore, India	75.2	1.5	0.1	0.2	0.9	3.1	19	0.146
Manila, Philippines	45.5	14.5	4.9	2.7	8.6	1.3	27.5	0.146
Asuncion, Paraguay	60.8	12.2	2.3	4.6	4.4	2.5	13.2	0.168
Mexico City, Mexico	59.8*	11.9	1.1	3.3	3.5	0.4	20	0.248
Bogota, Colombia	55.4*	18.3	1.6	4.6	16	3.8	0.3	0.270

PHYSICAL/CHEMICAL CHARACTERIZATION OF WASTE

1. Individual Components

2. Particle Size

3. Moisture content (%) = $\left(\frac{a-b}{a} \right) * 100$

Where a = initial mass of sample as delivered
b= mass of sample after drying

4. Density

PHYSICAL/CHEMICAL CHARACTERIZATION OF WASTE

$$\text{moisture content} = \frac{\text{mass of moisture}}{\text{total mass of waste}}$$

$$\text{dry mass} = \text{total mass of waste} \times \frac{100 - \text{moisture content (in \%)}}{100}$$

PHYSICAL/CHEMICAL CHARACTERIZATION OF WASTE

Table / 10.5

Common Physical/Chemical Characteristics of Solid-Waste Components

	Moisture (% by wet mass)	Energy Value as Received (MJ/kg)	Energy Value after Drying (MJ/kg)	Carbon (% by dry mass)	Hydrogen (% by dry mass)	Oxygen (% by dry mass)	Nitrogen (% by dry mass)	Sulfur (% by dry mass)	Ash (% by dry mass)
Food wastes	70	4.2	13.9	48	6.4	37.6	2.6	0.4	5
Magazines	4.1	12.2	12.7	32.9	5	38.6	0.1	0.1	23.3
Paper (mixed)	10	15.8	17.6	43.4	5.8	44.3	0.3	0.2	6
Plastics (mixed)	0.2	32.7	33.4	60	7.2	22.8	<0.1	<0.1	10
Textiles	10	18.5	20.5	48	6.4	40	2.2	0.2	3.2
Rubber	1.2	25.3	25.6	69.7	8.7	<0.1	<0.1	1.6	20
Leather	10	17.4	18.7	60	8	11.6	10	0.4	10
Yard wastes	60	6.0	15.1	46	6	38	3.4	0.3	6.3
Wood (mixed)	20	15.4	19.3	49.6	6	42.7	0.2	<0.1	1.5
Glass	2	0.2	0.2	0.5	0.1	0.4	<0.1	<0.1	99
Metals	4	0.6	0.7	4.5	0.6	4.3	<0.1	<0.1	90.6

Chemical Composition

Chemical content

$$\text{kJ/kg} = 337C + 1428 \left(H - \frac{O}{8} \right) + 9S$$

where C = carbon, percent

H = hydrogen, percent

O = oxygen, percent

S = Sulfur, percent

PHYSICAL/CHEMICAL CHARACTERIZATION OF WASTE

example/ 10.2 Adjusting for Varying Moisture Content of Waste

Food wastes can make up a significant fraction of a municipal solid-waste stream. In order to design a food waste collection system, a municipality is interested in determining the amount of food waste generated. The solid waste was analyzed on one particular day when it was found that the total annual waste generation was 700 kg/person-year. The study also showed that the food waste was 20 percent of the total (wet) mass of waste generated (see the following table). Thus, the rate of food waste generation is 140 kg/person-year.

The study did not, however, measure the moisture content of the waste. Assume that the waste percentage data were collected on a dry summer day with a low moisture content. Assuming a typical moisture content, estimate the food waste generation rate and the total waste generation rate.

	Percentage of Total Mass	Low Moisture Content (%)	Typical Moisture Content (%)
Food waste	20	50	70
Paper waste	30	3	10
Yard waste	30	20	60
Other waste	20	2	5

PHYSICAL/CHEMICAL CHARACTERIZATION OF WASTE

solution

First determine the dry generation rate of the various waste streams on a day when the waste has a low moisture content. This value can be converted to the typical dry generation rate (which is probably more applicable to the whole year). The total generation rate of each component of the solid-waste stream can be calculated and tabulated as given in Table 10.6. To estimate conditions on a day with a typical moisture content, determine the dry generation rate by using an assumed low moisture content (provided in the preceding table). Then add the typical moisture back to the dry generation rate.

Equations 10.1 and 10.2 can be combined to solve for the total mass as a function of dry mass and moisture content:

$$\text{total mass} = \frac{\text{dry mass}}{\frac{100 - \text{moisture content (in \%)}}{100}}$$

The results of our analysis are as given in Table 10.6.

The expected typical total generation rate of solid waste with typical moisture added is 1,024.1 kg/person-year, and the wet mass generation rate of food waste is 233.3 kg/person-year. These values are significantly higher than the sampled values (provided in the first column of Table 10.6), because the sampled values were determined on a relatively dry summer day.

PHYSICAL/CHEMICAL CHARACTERIZATION OF WASTE

Table / 10.6

Results for Example 10.2

	Sampled Total Generation Rate (kg/person-year)	Assumed Moisture Content (%)	Dry Generation Rate (kg/person-year)	Typical Moisture Content (%)	Typical Total Generation Rate (kg/person-year)
Food waste	140	50	70	70	233.3
Paper waste	210	3	203.7	10	226.3
Yard waste	210	20	168	60	420.0
Other waste	140	2	137.2	5	144.4
Total	700		578.9		1,024.1

Hazardous waste

Table / 10.7

Methods to Classify a Solid Waste as Hazardous

Characteristic of Waste	Question Related to Characteristic
Ignitable	Can the waste create a fire (e.g., waste solvents)?
Corrosive	Is the waste very acidic or basic and so able to corrode storage containers (e.g., battery acids)?
Reactive	Can the waste participate in rapid chemical reactions leading to explosions, toxic fumes, or excessive heat (e.g., lithium that can react with water explosively, explosives, cyanide sludge, strong oxidizing agents)?
Toxic	Can the waste cause internal damage to a person or organism (e.g., poisons causing death or blindness, carcinogens)?
Radioactive	Can the waste release subatomic particles that can cause toxic effects (e.g., some medical and laboratory wastes, wastes associated with nuclear energy production)?
Infectious	Can the waste lead to the transmission of disease (e.g., used syringes, hospital medical wastes)?

HIERARCHY OF WASTE MINIMIZATION

