8 Characterization

8.1 PHYSICAL AND CHEMICAL CHARACTERISTICS

This section addresses the characteristics of solid waste including fluctuations in quantity; composition, density, and other physical characteristics; combustion characteristics; bioavailability; and the presence of toxic substances.

Fluctuations in Solid Waste Quantities

Weakness in the economy generally reduces the quantity of solid waste generated. This reduction is particularly true for commercial and industrial MSW and construction and demolition debris. Data quantifying the effect of economic downturns on solid waste quantity are not readily available.

The generation of solid waste is usually greater in warm weather than in cold weather. Figure 8.1.1 shows two month-to-month patterns of MSW generation. The less variable pattern is a composite of data from eight locations with cold or moderately cold winters (Camp Dresser & McKee Inc. 1992, 1991; Child, Pollette, and Flosdorf 1986; Cosulich Associates 1988; HDR Engineering, Inc. 1989; Killam Associates 1990; North Hempstead 1986; Oyster Bay 1987). Waste generation is relatively low in the winter but rises with temperature in the spring. The surge of waste generation in the spring is caused both by increased human activity, including spring cleaning, and renewed plant growth and associated yard waste. Waste generation typically declines somewhat after June but remains above average until mid to late fall. In contrast, Figure 8.1.1 also shows the pattern of waste generation in Cape May County, New Jersey, a summer resort area (Camp Dresser & McKee Inc. 1991). The annual influx of tourists overwhelms all other influences of waste generation.

Areas with mild winters may display month-to-month patterns of waste generation similar to the cold-winter pattern shown in Figure 8.1.1 but with a smaller difference between the winter and spring/summer rates. On the other hand, local factors can create a distinctive pattern not generally seen in other areas, as in Sarasota, Florida (Camp Dresser & McKee Inc. 1990). The surge of activity and plant growth in the spring is less marked in mild climates, and local factors can cause the peak of waste generation to occur in any season of the year.

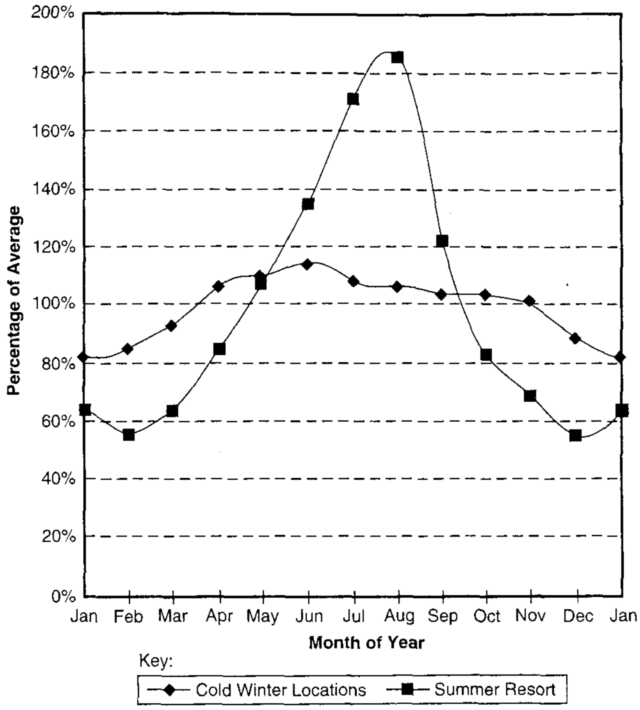

FIG. 2.1.1 Month-to-month variation in MSW generation rate.

Component Composition of MSW

Table 8.1.1 lists the representative component composition for MSW disposed in the United States and adjacent portions of Canada and shows ranges for individual components. Materials diverted from the waste stream for recycling or composting are not included. The table is based on the results of twenty-two field studies in eleven states plus the Canadian province of British Columbia. The ranges shown in the table are annual values for county-sized areas. Seasonal values may be outside these ranges, especially in individual municipalities.

TABLE 8.1.1 REPRESENTATIVE COMPONENT COMPOSITION OF MSW

Waste Category	*Representative Composition (%)*[b]	*Range of Reasonable Reported Values (%)*[b]
Organics/Combustibles	86.6	—
Paper	39.8	—
Newspaper	6.8	4.0–13.1
Corrugated	8.6	3.5–14.8
Kraft	1.5	0.5–2.3
Corrugated & kraft	10.1	5.4–15.6
Other paper[a]	22.9	17.6–30.6
High-grade paper	1.7	0.6–3.2
Other paper[a]	21.2	16.9–25.4
Magazines	2.1	1.0–2.9
Other paper[a]	19.1	12.5–23.7
Office paper	3.4	2.5–4.5
Magazines & mail	4.0	3.6–5.7
Other paper[a]	17.2	—
Yard waste	9.7	2.8–19.6
Grass clippings	4.0	0.3–6.5
Other yard waste	5.7	—
Food waste	12.0	6.8–17.3
Plastic	9.4	6.3–12.6
Polyethylene terephthalate (PET) bottles	0.4	0.1–0.5
High-density polyethylene (HDPE) bottles	0.7	0.4–1.1
Other plastic	8.3	5.8–10.2
Polystyrene	1.0	0.5–1.5
Polyvinyl chloride (PVC) bottles	0.06	0.02–0.1
Other plastic[a]	7.2	5.3–9.5
Polyethylene bags & film	3.7	3.5–4.0
Other plastic[a]	3.5	2.8–4.4
Other organics	15.7	—
Wood	4.0	1.0–6.6
Textiles	3.5	1.5–6.3
Textiles/rubber/leather	4.5	2.6–9.2
Fines	3.3	2.8–4.0
Fines $<\frac{1}{2}$ inch	2.2	1.7–2.8
Disposable diapers	2.5	1.8–4.1
Other organics	1.4	—
Inorganics/Noncombustibles	13.4	—
Metal	5.8	—
Aluminum	1.0	0.6–1.2
Aluminum cans	0.6	0.3–1.2
Other aluminum	0.4	0.2–0.9
Tin & bimetal cans	1.5	0.9–2.7
Other metal[a]	3.3	1.1–6.9
Ferrous metal	4.5	2.8–5.5
Glass	4.8	2.3–9.7
Food & beverage containers	4.3	2.0–7.7
Other glass	0.5	—
Batteries	0.1	0.04–0.1
Other Inorganics		
With noncontainer glass	3.2	1.9–4.9
Without noncontainer glass	2.7	1.8–3.8

[a]Each "other" category contains all material of its type except material in the categories above it.
[b]Weight percentage

Residential MSW contains more newspaper; yard waste; disposable diapers; and textiles, rubber, and leather. Nonresidential MSW contains more corrugated cardboard, high-grade paper, wood, other plastics, and other metals.

The composition of MSW varies from one CII establishment to another. However, virtually all businesses and institutions generate a variety of waste materials. For example, offices do not generate only paper waste, and restaurants do not generate only food waste.

Component Composition of Bulky Waste

Fewer composition data are available for bulky waste than for MSW. Table 8.1.2 shows the potential range of compositions. The first column in the table shows the composition of all bulky waste generated in two adjacent counties in southern New Jersey, including bulky waste reported as recycled. The third column shows the composition of bulky waste disposed in the two counties, and the middle column shows the estimated recycling rate for each bulky waste component based on reported recycling and disposal. Note that the estimated overall recycling rate is almost 80%.

The composition prior to recycling is dramatically different from the composition after recycling. For example, inorganic materials account for roughly three quarters of the bulky waste before recycling but little more than one quarter after recycling. Depending on local recycling practices, the composition of bulky waste received at a disposal facility in the United States could be similar to the first column of Table 8.1.2, similar to the third column, or anywhere in between.

The composition of MSW does not change dramatically from season to season. Even the most variable component, yard waste, may be consistent in areas with mild climates. In areas with cold winters, generation of yard waste generally peaks in the late spring, declines gradually through the summer and fall, and is lowest in January and February. A surge in yard waste can occur in mid to late fall in areas where a large proportion of tree leaves enter the solid waste stream and are not diverted for composting or mulching.

Density

As discussed in Section 7.2, the density of MSW varies according to circumstance. Table 8.1.3 shows representative density ranges for MSW under different conditions. The density of mixed MSW is influenced by the degree of compaction, moisture content, and component composition. As shown in the table, individual components of MSW have different bulk densities, and a range of densities exists within most components.

TABLE 8.1.2 COMPONENT COMPOSITION OF BULKY WASTE AND THE POTENTIAL IMPACT OF RECYCLING

Waste Category	*Composition of all Bulky Waste Generated (%)*[a]	*Composition of Bulky Waste Recycled (%)*[a]	*Composition of Bulky Waste Landfilled (%)*[a]
Organics/Combustibles	24.7	37.9	73.4
Lumber	13.1	47.2	33.0
Corrugated cardboard	0.7	2.5	3.1
Plastic	1.0	18.8	3.7
Furniture	1.3	0.0	6.3
Vegetative materials	3.8	73.0	4.9
Carpet & padding	0.7	0.0	3.2
Bagged & miscellaneous	2.1	0.0	10.2
Roofing materials	1.2	0.4	5.9
Tires	0.3	100.0	0.0
Other	0.6	0.0	3.1
Inorganics/Noncombustibles	75.3	92.6	26.6
Gypsum board & plaster	1.8	3.9	8.3
Metal & appliances	15.4	92.5	5.5
Dirt & dust	1.2	0.0	5.8
Concrete	26.5	96.7	4.2
Asphalt	28.7	99.9	0.1
Bricks & blocks	1.3	81.8	1.1
Other	0.3	0.0	1.6
Overall	100.0	79.1	100.0

Sources: Data from Camp Dresser & McKee, 1992, *Atlantic County (NJ) Solid Waste Characterization Program* (Edison, N.J. [May]) and *Idem*, 1991, *Cape May County Multi-Seasonal Solid Waste Composition Study* (Edison, N.J. [August]).
[a]Weight percentage

TABLE 8.1.3 DENSITY OF MSW AND COMPONENTS

Material and Circumstance	*Density (lb/cu yd)*
Mixed MSW	
Loose	150–300
In compactor truck	400–800
Dumped from compactor truck	300–500
Baled	800–1600
In landfill	800–1400
Loose Bulk Densities	
Aluminum cans (uncrushed)	54–81
Corrugated cardboard	50–135
Dirt, sand, gravel, concrete	2000–3000
Food waste	800–1500
Glass bottles (whole)	400–600
Light ferrous, including cans	100–250
Miscellaneous paper	80–250
Stacked high-grade paper	400–600
Plastic	60–150
Rubber	200–400
Textiles	60–180
Wood	200–600
Yard waste	100–600

Within individual categories of MSW, bulk density increases as physical irregularity decreases. Compaction increases density primarily by reducing irregularity. Some compaction occurs in piles, so density tends to increase as the height of a pile increases. In most cases, shredding and other size reduction measures also increase density by reducing irregularity. The size reduction of regularly shaped materials such as office paper, however, can increase irregularity and decrease density.

Particle Size, Abrasiveness, and Other Physical Characteristics

Figure 8.1.2 shows a representative particle size distribution for MSW based on research by Hilton, Rigo, and Chandler (1992). Environmental engineers generally estimate size distribution by passing samples of MSW over a series of screens, beginning with a fine screen and working up to a coarse screen. As shown in the figure, MSW has no characteristic particle size, and most components of MSW have no characteristic particle size.

MSW does not flow, and piles of MSW have a tendency to hold their shape. Loads of MSW discharged from compactor trucks often retain the same shape they had in-

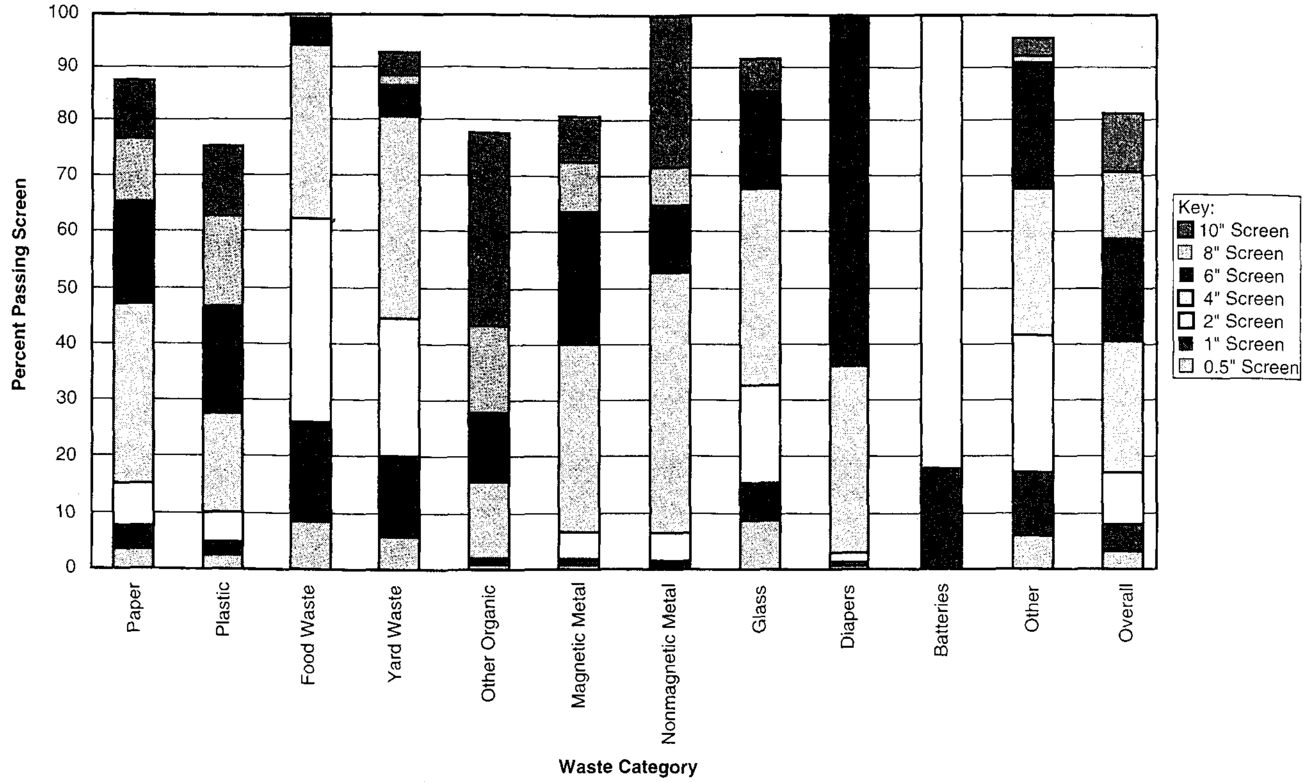

FIG. 8.1.2 Representative size distribution of MSW. (Adapted from D. Hilton, H.G. Rigo, and A.J. Chandler, 1992, Composition and size distribution of a blue-box separated waste stream, presented at *SWANA's Waste-to-Energy Symposium, Minneapolis, MN, January 1992.*)

side the truck. When MSW is removed from one side of a storage bunker at an MSW combustion facility, the waste on the other side generally does not fall into the vacated space. This characteristic allows the side on which trucks dump waste be kept relatively empty during the hours when the facility receives waste.

MSW tends to stratify vertically when mixed, with smaller and denser objects migrating toward the bottom and lighter and bulkier objects moving toward the top. However, MSW does not stratify much when merely vibrated.

Although MSW is considered soft and mushy, it contains substantial quantities of glass, metal, and other potentially abrasive materials.

Combustion Characteristics

Most laboratory work performed on samples of solid waste over the years has focused on parameters related to combustion and combustion products. The standard laboratory tests in this category are proximate composition, ultimate composition, and heat value.

PROXIMATE COMPOSITION

The elements of proximate composition are moisture, ash, volatile matter, and fixed carbon. The moisture content of solid waste is defined as the material lost during one hour at 105°C. Ash is the residue remaining after combustion. Together, moisture and ash represent the noncombustible fraction of the waste.

Volatile matter is the material driven off as gas or vapor when waste is subjected to a temperature of approximately 950°C for 7 min but is prevented from burning because oxygen is excluded. Volatile matter should not be confused with *volatile organic compounds* (VOCs). VOCs are a small component of typical solid waste. In proximate analysis, any VOCs present tend to be included in the result for moisture.

Conceptually, fixed carbon is the combustible material remaining after the volatile matter is driven off. Fixed carbon represents the portion of combustible waste that must be burned in the solid state rather than as gas or vapor. The value for fixed carbon reported by the laboratory is calculated as follows:

$$\% \text{ fixed carbon} = 100\% - \% \text{ moisture} - \% \text{ ash} - \% \text{ volatile matter} \quad 8.1(1)$$

Table 8.1.4 shows a representative proximate composition for MSW. The values in the table are percentages based on dry (moisture-free) MSW. Representative moisture values are also provided. These moisture values are for MSW and components of MSW as they are received at a disposal facility. Because of a shortage of data for the proximate composition of noncombustible materials, these materials are presented as 100% ash.

The dry-basis values in Table 8.1.4 can be converted to as-received values by using the following equation:

$$A = D(100\% - M) \qquad 8.1(2)$$

where:

A = value for waste as received at the solid waste facility
D = dry-basis value
M = percent moisture for waste received at the solid waste facility

Between initial discard at the point of generation and delivery to a central facility, moisture moves from wet materials to dry and absorbent materials. The largest movement of moisture is from food waste to uncoated paper discarded with food waste. This paper includes newspaper, kraft paper, and a substantial portion of other paper from residential sources as well as corrugated cardboard from commercial sources.

Other sources of moisture in paper waste include water absorbed by paper towels, napkins, and tissues during use, and precipitation. Absorbent materials frequently exposed to precipitation include newspaper and corrugated cardboard. Many trash containers are left uncovered, and precipitation is absorbed by the waste. Standing water in dumpsters is often transferred to the collection vehicle.

The value of proximate analysis is limited because (1) it does not indicate the degree of oxidation of the combustible waste and (2) it gives little indication of the quantities of pollutants emitted during combustion of the waste. Ultimate analysis supplements the information provided by proximate analysis.

TABLE 8.1.4 REPRESENTATIVE PROXIMATE AND ULTIMATE COMPOSITION OF MSW

	Proximate Composition—Dry Basis			*Ultimate Composition—Dry Basis*[a]						
Waste Category	*Ash (%)*	*Volatile Matter (%)*	*Fixed Carbon (%)*	*Carbon (%)*	*Hydrogen (%)*	*Nitrogen (%)*	*Chlorine (%)*	*Sulfur (%)*	*Oxygen (%)*	*Moisture (%)*
Organics/Combustibles	7.7	82.6	9.6	48.6	6.8	0.94	0.69	0.22	35.0	32.5
Paper	6.3	83.5	10.1	43.0	6.0	0.36	0.17	0.17	43.8	24.0
Newspaper	5.2	83.8	11.1	43.8	5.9	0.29	0.14	0.24	44.4	23.2
Corrugated & kraft paper	2.2	85.8	12.1	46.0	6.4	0.28	0.14	0.22	44.8	21.2
High-grade paper	9.1	83.4	7.5	38.1	5.6	0.15	0.12	0.07	46.9	9.3
Magazines	20.4	71.8	7.9	35.0	5.0	0.05	0.07	0.08	39.4	8.6
Other paper	6.9	83.8	9.3	42.7	6.1	0.50	0.22	0.14	43.3	28.7
Yard waste	9.6	73.0	17.4	45.0	5.6	1.5	0.31	0.17	37.7	53.9
Grass clippings	9.7	75.6	14.7	43.3	5.9	2.6	0.60	0.30	37.6	63.9
Leaves	7.3	72.7	20.1	50.0	5.7	0.82	0.10	0.10	36.0	44.0
Other yard waste	12.5	70.5	17.0	40.7	5.0	1.3	0.26	0.10	40.0	50.1
Food waste	11.0	79.0	10.0	45.4	6.9	3.3	0.74	0.32	32.3	65.4
Plastic	5.3	93.0	1.3	76.3	11.5	0.26	2.4	0.20	4.4	13.3
PET bottles	1.3	95.0	3.6	68.5	8.0	0.16	0.08	0.08	21.9	3.6
HDPE bottles	2.4	97.4	0.2	81.6	13.6	0.10	0.18	0.20	1.9	7.0
Polystyrene	1.8	97.8	0.4	86.3	7.9	0.28	0.12	0.30	3.4	10.8
PVC bottles	0.6	46.2	3.2	44.2	5.9	0.26	40.1	0.89	7.6	3.2
Polyethylene bags & film	8.8	90.1	1.1	77.4	12.9	0.10	0.09	0.12	1.8	19.1
Other plastic	4.2	94.1	1.7	72.9	11.4	0.45	5.3	0.24	5.5	10.5
Other Organics	11.3	77.8	10.9	46.2	6.1	1.9	1.0	0.36	33.3	27.3
Wood	2.8	83.0	14.1	46.7	6.0	0.71	0.12	0.16	43.4	14.8
Textiles/rubber/leather	6.6	84.0	9.4	50.3	6.4	3.3	1.8	0.33	31.3	12.4
Fines	25.3	64.7	10.0	37.3	5.3	1.6	0.54	0.45	29.5	41.1
Disposable diapers	4.1	87.1	8.7	48.4	7.6	0.51	0.23	0.35	38.8	66.9
Other organics	31.3	58.8	9.9	44.2	5.3	1.8	2.2	0.81	14.4	8.0
Inorganics/Noncombustibles[b]	100	0	0	0	0	0	0	0	0	0
Overall	24.9	67.2	7.8	39.5	5.6	0.76	0.56	0.18	28.5	28.2

[a]Also includes ash values from first column of proximate analysis.
[b]Values assumed for the purpose of estimating overall values.

ULTIMATE COMPOSITION

Moisture and ash, as previously defined for proximate composition, are also elements of ultimate composition. In standard ultimate analysis, the combustible fraction is divided among carbon, hydrogen, nitrogen, sulfur, and oxygen. Ultimate analysis of solid waste should also include chlorine. The results are more useful if sulfur is broken down into organic sulfur, sulfide, and sulfate; and chlorine is broken down into organic (insoluble) and inorganic (soluble) chlorine (Niessen 1995).

Carbon, hydrogen, nitrogen, sulfur, and chlorine are measured directly; calculating oxygen requires subtracting the sum of the other components (including moisture and ash) from 100%. Table 8.1.4 shows a representative ultimate composition for MSW. The dry-basis values shown in the table can be converted to as-received values with use of Equation 8.1(2).

The ultimate composition of MSW on a dry basis reflects the dominance of six types of materials in MSW: cellulose, lignins, fats, proteins, hydrocarbon polymers, and inorganic materials. Cellulose is approximately 42.5% carbon, 5.6% hydrogen, and 51.9% oxygen and accounts for the majority of the dry weight of MSW. The cellulose content of paper ranges from approximately 75% for low grades to approximately 90% for high-grade paper. Wood is roughly 50% cellulose, and cellulose is a major ingredient of yard waste, food waste, and disposable diapers. Cotton, the largest ingredient of the textile component of MSW, is approximately 98% cellulose (Masterton, Slowinski, and Stanitski 1981).

Despite the abundance of cellulose, MSW contains more carbon than oxygen due to the following factors:

- Most of the plastic fraction of MSW is composed of polyethylene, polystyrene, and polypropylene, which contain little oxygen.
- Synthetic fibers (textiles category) contain more carbon than oxygen, and rubber contains little oxygen.
- The lower grades of paper contain significant quantities of lignins, which contain more carbon than oxygen.
- Fats contain more carbon than oxygen.

The nitrogen in solid waste is primarily in organic form. The largest contributors of nitrogen to MSW are food waste (proteins), grass clippings (proteins), and textiles (wool, nylon, and acrylic). Chlorine occurs in both organic and inorganic forms. The largest contributor of organic chlorine is PVC or vinyl. Most of the PVC is in the other plastic and textiles components. The largest source of inorganic chlorine is sodium chloride (table salt). Sulfur is not abundant in any category of combustible MSW but is a major component of gypsum board. The sulfur in gypsum is largely noncombustible but not entirely so. In Table 8.1.4, gypsum board is included in the Inorganics/Noncombustibles category, which is shown as 100% ash because of a lack of data on the ultimate composition.

The inorganic (noncombustible) waste categories contribute most of the ash in MSW. Additional ash is contributed by the inorganic components of combustible materials, including clay in glossy and high-grade paper, dirt in yard waste, bones and shells in food waste, asbestos in vinyl–asbestos floor coverings, fiberglass in reinforced plastic, and grit on roofing shingles.

HEAT VALUE

Table 8.1.5 shows the heat value of typical MSW based on the results of laboratory testing of MSW components. Calculations of the heat value based on energy output measurements at operating combustion facilities generally yield lower values (see Section 8.3).

The heat value shown for solid waste and conventional fuels in the United States, Canada, and the United Kingdom is typically the higher heating value (HHV). The HHV includes the latent heat of vaporization of the water created during combustion. When this heat is deducted, the result is called the lower heating value (LHV). For additional information see Niessen (1995).

The as-received heat value is roughly proportional to the percentage of waste that is combustible (i.e., neither moisture nor ash) and to the carbon content of the combustible fraction. The heat values of the plastics categories are highest because of their high carbon content, low ash content, and low-to-moderate moisture content. Paper categories have intermediate heat values because of their intermediate carbon content, moderate moisture content, and low-to-moderate ash content. Yard waste, food waste, and disposable diapers have low heat values because of their high moisture levels.

Bioavailability

Because microorganisms can metabolize paper, yard waste, food waste, and wood, this waste is classified as *biodegradable.* Disposable diapers and their contents are also largely biodegradable, as are cotton and wool textiles.

Some biodegradable waste materials are more readily metabolized than others. The most readily metabolized materials are those with high nitrogen and moisture content: food waste, grass clippings, and other green, pulpy yard wastes. These wastes are *putrescible* and have high *bioavailability.* Leaf waste generally has intermediate bioavailability. Wood, cotton and wool, although biodegradable, have relatively low bioavailability and are considered noncompostable within the context of solid waste management.

Toxic Substances in Solid Waste

Solid waste inevitably contains many of the toxic substances manufactured or extracted from the earth. Most

TABLE 8.1.5 REPRESENTATIVE HEAT VALUES OF MSW[a]

Waste Category	*Dry-Basis Heat Value (HHV in Btu/lb)*	*Moisture Content (%)*	*As-Received Heat Value (HHV in Btu/lb)*
Organics/Combustibles	9154	32.5	6175
Paper	7587	24.0	5767
Newspaper	7733	23.2	5936
Corrugated & kraft	8168	21.2	6435
High-grade paper	6550	9.3	5944
Magazines	5826	8.6	5326
Other paper	7558	28.7	5386
Yard waste	7731	53.9	3565
Grass clippings	7703	63.9	2782
Leaves	8030	44.0	4499
Other yard waste	7387	50.1	3689
Food waste	8993	65.4	3108
Plastic	16,499	13.3	14,301
PET bottles	13,761	3.6	13,261
HDPE bottles	18,828	7.0	17,504
Polystyrene	16,973	10.8	15,144
PVC bottles	10,160	3.2	9838
Polyethylene bags & film	17,102	19.1	13,835
Other plastic	15,762	10.5	14,108
Other organics	8698	27.3	6322
Wood	8430	14.8	7186
Textiles/rubber/leather	9975	12.4	8733
Fines	6978	41.1	4114
Disposable diapers	9721	66.9	3222
Other organics	7438	8.0	6844
Inorganics/Noncombustibles[b]	0	0.0	0
Overall	7446	28.2	5348

[a]Values shown are HHV. In HHV measurements, the energy required to drive off the moisture formed during combustion is not deducted.
[b]Values assumed for the purpose of estimating overall values.

toxic material in solid waste is in one of three categories:

- Toxic metals
- Toxic organic compounds, many of which are also flammable
- Asbestos

The results of studies of toxic metals in solid waste vary. Table 8.1.6 summarizes selected results of two comprehensive studies performed in Cape May County, New Jersey (Camp Dresser & McKee Inc. 1991a) and Burnaby, British Columbia (Chandler & Associates, Ltd. 1993; Rigo, Chandler, and Sawell 1993). Reports of both studies contain data for additional metals and materials, and the Burnaby reports contain results for numerous subcategories of the categories in the table. The Burnaby reports also analyze the behavior of specific metals from waste components during processing in an MSW incinerator.

Franklin Associates, Ltd. (1989) provided extensive information on sources of lead and cadmium in MSW, and Rugg and Hanna (1992) compiled detailed information on sources of lead in MSW in the United States.

Most MSW referred to as *household hazardous waste* is so classified because it contains toxic organic compounds. Large quantities of toxic organic materials from commercial and industrial sources were once disposed in MSW landfills in the United States, and many of these landfills are now officially designated as hazardous waste sites. The large-scale disposal of toxic organics in MSW landfills has been largely eliminated, but disposal of household hazardous waste remains a concern for many. Generally, household hazardous waste refers to whatever toxic materials remain in MSW, regardless of the source.

Estimates of the abundance of household hazardous waste vary. Reasons for the lack of consistency from one

TABLE 8.1.6 REPORTED METAL CONCENTRATIONS IN COMPONENTS OF MSW[a]

	Arsenic		*Cadmium*		*Chromium*		*Copper*		*Lead*		*Mercury*		*Nickel*		*Zinc*	
Waste Category	*CM*	*BC*	*CM*	*BC*	*CM*	*BC*	*CM*	*BC*	*CM*	*BC*	*CM*	*BC*	*CM*	*BC*	*CM*	*BC*
Organics/Combustibles																
Paper																
Newspaper	0.1	0.7	ND[b]	0.1	ND	49	17	18	ND	7	0.3	2	ND	28	58	21
Corrugated cardboard	0.2	0.6	ND	0.1	ND	2	13	3	19	4	0.2	0.1	6	4	56	10
Kraft paper	0.3	0.8	ND	0.1	5	5	11	11	15	9	0.1	0.5	ND	8	30	22
High-grade paper	0.7	1	ND	0.1	ND	3	7	8	ND	5	0.1	0.3	ND	8	28	208
Magazines	0.4	1	ND	0.2	4	11	46	32	ND	3	0.09	0.3	ND	13	88	27
Other	0.4	1	ND	1	4	27	52	25	9	182	0.07	0.3	ND	7	58	71
Yard waste	0.9	6	ND	5	4	87	10	571	14	137	0.1	1	3	21	89	321
Food waste	0.1	1	ND	2	ND	23	9	43	ND	72	0.02	0.3	2	5	20	186
Plastic																
PET	ND	0.8	ND	5	15	17	30	31	59	62	0.07	0.2	ND	8	21	97
HDPE	0.2	0.5	ND	3	52	15	14	24	211	61	0.1	0.2	ND	7	58	142
Film	0.5	0.6	ND	5	100	102	25	23	450	325	0.1	0.2	ND	7	120	658
Other	0.4	0.7	8	82	7	279	8	58	19	342	0.04	0.3	ND	40	69	231
Other organics																
Wood	34	24	ND	0.4	52	77	32	68	108	408	2	0.3	ND	3	205	174
Textiles & footwear	0.8	0.4	19	4	387	619	25	62	48	129	0.3	1	5	1	666	222
Fines	3	7	1	4	14	115	179	243	273	259	0.2	1	18	54	352	654
Disposable diapers	0.1	—	ND	—	1	—	2	—	ND	—	0.02	—	ND	—	28	—
Inorganics/Noncombustibles																
Metal																
Ferrous food & beverage cans	4	7	16	43	527	191	375	104	350	342	0.8	6	133	161	145	1552
Aluminum beverage cans	ND	0.4	ND	5	72	91	107	1105	30	41	0.7	0.4	54	21	80	229
Other metal	9	280	22	25	4702	768	6816	2082	1279	95	0.7	0.4	411	24	1675	199,000
Glass food & beverage containers	ND	2	ND	4	ND	91	ND	26	84	103	0.2	0.2	ND	15	ND	71
Household batteries																
Carbon-zinc & alkaline batteries[c]	7	2	53	1027	45	57	8400	6328	236	94	2900	136	—	512	180,000	103,000
Nickel-cadmium batteries	—	4	175,000	120,000	—	64	—	53	—	113	—	0.3	240,000	315	—	685
Other inorganics	1	12	ND	8	21	91	13	113	50	607	0.9	0.2	5	73	21	1997

Source: Data adapted from Camp Dresser & McKee Inc., 1991a, *Cape May County multi-seasonal solid waste composition study* (Edison, N.J. [August]); A.J. Chandler & Associates, Ltd. et al., 1993, *Waste analysis, sampling, testing and evaluation (WASTE) program: Effect of waste stream characteristics on MSW incineration: The fate and behaviour of metals. Final report of the mass burn MSW incineration study (Burnaby, B.C.),* Vol. 1, Summary report (Toronto [April]); and H.G. Rigo, A.J. Chandler, and S.E. Sawell, 1993, Debunking some myths about metals, in *Proceedings of the 1993 International Conference on Municipal Waste Combustion* (Williamsburg, Va. [30 March–2 April]).

[a]All values in mg/kg on an as-received basis. Values presented are based on reported results from studies in Cape May County, New Jersey and Burnaby, British Columbia. CM indicates Cape May, and BC indicates Burnaby.

[b]ND = Not detected.

[c]Current values for mercury are close to or below the Burnaby value.

study to another include the following:

Some quantity estimates include less toxic materials such as latex paint.

Most quantity estimates include the weight of containers, and many estimates include the containers even if they are empty.

Some quantity estimates include materials that were originally in liquid or paste form but have dried, such as dried paint and adhesives. Toxic substances can still leach from these dried materials, but drying reduces the potential leaching rate.

Strongly toxic organic materials, excluding their containers, appear to constitute well under 0.5% of MSW, and the toxic material is usually dispersed. Bulky waste typically contains no more toxic organic material than MSW, but bulky waste is more likely to contain concentrated pockets of toxic substances.

A statewide waste characterization study in Minnesota (Minnesota Pollution Control Agency 1992; Minnesota Pollution Control Agency and Metropolitan Council 1993) provides a detailed accounting of the household hazardous waste materials encountered.

Most of the asbestos in normal solid waste is in old vinyl–asbestos floor coverings and asbestos shingles. Asbestos in these forms is generally not a significant hazard.

—F. Mack Rugg

References

Camp Dresser & McKee Inc. 1990. *Sarasota County waste stream composition study.* Draft report (March).

———. 1991a. *Cape May County multi-seasonal solid waste composition study.* Edison, N.J. (August).

———. 1991b. *Cumberland County (NJ) waste weighing and composition analysis.* Edison, N.J. (January).

———. 1992. *Atlantic County (NJ) solid waste characterization program.* Edison, N.J. (May).

Chandler, A.J., & Associates, Ltd. et al. 1993. *Waste analysis, sampling, testing and evaluation (WASTE) program: Effect of waste stream characteristics on MSW incineration: The fate and behaviour of metals. Final report of the mass burn MSW incineration study (Burnaby, B.C.). Volume I, Summary report.* Toronto (April).

Child, D., G.A. Pollette, and H.W. Flosdorf. 1986. Waste stream analysis. *Waste Age* (November).

Cosulich, William F., Associates, P.C. 1988. *Solid waste management plan, County of Monroe, New York: Solid waste quantification and characterization.* Woodbury, N.Y. (July).

Franklin Associates, Ltd. 1989. *Characterization of products containing lead and cadmium in municipal solid waste in the United States, 1970 to 2000.* U.S. EPA (January).

HDR Engineering, Inc. 1989. *Report on solid waste quantities, composition and characteristics for Monmouth County (NJ) waste recovery system.* White Plains, N.Y. (March).

Killam Associates. 1990. *Somerset County (NJ) solid waste generation and composition study.* Millburn, N.J. (May).

Masterton, W.L., E.J. Slowinski, and C.L. Stanitski. 1981. *Chemical principles.* 5th ed. Philadelphia: Saunders College Publishing.

Minnesota Pollution Control Agency. 1992. *Minnesota solid waste composition study, 1990–1991 part I.* Saint Paul, Minn. (November).

Minnesota Pollution Control Agency and Metropolitan Council. 1993. *Minnesota solid waste composition study, 1991–1992 part II.* Saint Paul, Minn. (April).

Niessen, W.R. 1995. *Combustion and incineration processes: Applications in environmental engineering.* 2d ed. New York: Marcel Dekker, Inc.

North Hempstead, Town of (NY), transfer station scalehouse records, August 1985 through July 1986. 1986.

Oyster Bay, Town of (NY), transfer station scalehouse records, September 1986 through August 1987. 1987.

Rigo, H.G., A.J. Chandler, and S.E. Sawell. Debunking some myths about metals. In *Proceedings of the 1993 International Conference on Municipal Waste Combustion, Williamsburg, VA, March 30–April 2, 1993.*

Rugg, M. and N.K. Hanna. 1992. Metals concentrations in compostable and noncompostable components of municipal solid waste in Cape May County, New Jersey. *Proceedings of the Second United States Conference on Municipal Solid Waste Management, Arlington, VA, June 2–5, 1992.*