CHAPTER 3

SOURCES, TYPES, AND COMPOSITION OF MUNICIPAL SOLID WASTES

Solid wastes include all solid or semisolid materials that the possessor no longer considers of sufficient value to retain. The management of these waste materials is the fundamental concern of all the activities encompassed in solid waste management—whether the planning level is local, regional or subregional, or state and federal. For this reason, it is important to know as much about municipal solid waste (MSW) as possible. Important questions that must be answered include the following [5]:

1. What types and quantities of MSW will be received?
2. At what rates will these types arrive?
3. What types and quantities of materials have already been removed for reuse and recycling?
4. What properties does MSW have as it is received?
5. How do the properties of MSW vary: hourly, daily, weekly, and seasonally?
6. How do the properties of MSW change during processing?
7. How can the properties of MSW be changed during processing?
8. What are the properties of MSW that are of economic value?
9. What unwieldy or hazardous objects must be removed?
10. What contaminants should be removed?

11. What tests and measurements can be performed to obtain answers to the above questions?
12. What range of variations should be expected in the measured quantities and with what level of confidence?

The purpose of this chapter is to identify the sources, types, and composition of solid wastes. The physical, chemical, and biological properties and transformations of waste materials are considered in Chapter 4. The sources and properties of the small amounts of hazardous waste found in MSW are considered in Chapter 5. Data on the quantities of waste generated and their variation and information on the types and quantities of waste materials now recovered from MSW are presented in Chapter 6. Information presented in this and the following two chapters will have application throughout the remainder of this text.

3-1 SOURCES OF SOLID WASTES

Knowledge of the sources and types of solid wastes, along with data on the composition and rates of generation, is basic to the design and operation of the functional elements associated with the management of solid wastes. To avoid confusion, the term *refuse*, often used interchangeably with the term *solid wastes*, is not used in this text.

Sources of solid wastes in a community are, in general, related to land use and zoning. Although any number of source classifications can be developed, the following categories are useful: (1) residential, (2) commercial, (3) institutional, (4) construction and demolition, (5) municipal services, (6) treatment plant sites, (7) industrial, and (8) agricultural. Typical waste generation facilities, activities, or locations associated with each of these sources are reported in Table 3-1, where *municipal solid waste* (MSW) is normally assumed to include all community wastes with the exception of industrial process wastes and agricultural wastes.

3-2 TYPES OF SOLID WASTES

As a basis for subsequent discussions, it will be helpful to define the various types of solid wastes that are generated (see Table 3-1). It is important to be aware that the definitions of solid waste terms and the classifications vary greatly in the literature and in the profession. Consequently, the use of published data requires considerable care, judgment, and common sense. The following definitions are intended to serve as a guide and are not meant to be precise in a scientific sense.

Residential and Commercial

Residential and commercial solid wastes, excluding special and hazardous wastes discussed below, consist of the organic (combustible) and inorganic (noncombustible) solid wastes from residential areas and commercial establishments. Typically,

TABLE 3-1
Sources of solid wastes within a community[a]

Source	Typical facilities, activities, or locations where wastes are generated	Types of solid wastes
Residential	Single family and multifamily detached dwellings, low-, medium-, and high-rise apartments, etc.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cans, aluminum, other metals, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), household hazardous wastes
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops, etc.	Paper, cardboard, plastics, wood, food waste, glass, metals, special wastes (see above), hazardous wastes, etc.
Institutional	Schools, hospitals, prisons, governmental centers	As above in commercial
Construction and demolition	New construction sites, road repair/renovation sites, razing of buildings, broken pavement	Wood, steel, concrete, dirt, etc.
Municipal services (excluding treatment facilities)	Street cleaning, landscaping, catch basin cleaning, parks and beaches, other recreational areas	Special wastes, rubbish, street sweepings, landscape and tree trimmings, catch basin debris, general wastes from parks, beaches, and recreational areas
Treatment plant sites; municipal incinerators	Water, wastewater, and industrial treatment processes, etc.	Treatment plant wastes, principally composed of residual sludges
Municipal solid waste[b]	All of the above	All of the above
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc. Non-industrial wastes including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, hazardous wastes
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes

[a] For comparison, the sources of waste and waste classifications used in the early 1900s are given in Table 3-12.

[b] The term *municipal solid waste* (MSW) normally is assumed to include all of the wastes generated in a community with the exception of industrial process wastes and agricultural solid wastes.

the organic fraction of residential and commercial solid waste consists of materials such as food waste (also called garbage), paper of all types, cardboard (also known as paperboard and corrugated paper), plastics of all types, textiles, rubber, leather, wood, and yard wastes. The inorganic fraction consists of items such as glass, crockery, tin cans, aluminum, ferrous metals, and dirt. If the waste components are not separated when discarded, then the mixture of these wastes is also known as *commingled residential and commercial MSW.*

Wastes that will decompose rapidly, especially in warm weather, are also known as putrescible waste. The principal source of putrescible wastes is the handling, preparation, cooking, and eating of foods. Often, decomposition will lead to the development of offensive odors (see Section 4-3) and the breeding of flies. In many locations, the putrescible nature of these wastes will influence the design and operation of the solid waste collection system (see Chapter 8).

Although there are more than 40 classifications for paper, the waste paper found in MSW is typically composed of newspaper, books and magazines, commercial printing, office paper, other paperboard, paper packaging, other non-packaging paper, tissue paper and towels, and corrugated cardboard.

The plastic materials found in MSW fall into the following seven categories:

- Polyethylene terephthalate (PETE/1)
- High-density polyethylene (HDPE/2)
- Polyvinyl chloride (PVC/3)
- Low-density polyethylene (LDPE/4)
- Polypropylene (PP/5)
- Polystyrene (PS/6)
- Other multilayered plastic materials (7)

The type of plastic container can be identified by number code (1 through 7) molded into the bottom of the container (see Fig. 3-1). *Mixed plastic* is the term used for the mixture of the individual types of plastic found in MSW.

Special Wastes. Special wastes from residential and commercial sources include bulky items, consumer electronics, white goods, yard wastes that are collected

FIGURE 3-1
Code designation used for various types of plastics.

separately, batteries, oil, and tires. These wastes are usually handled separately from other residential and commercial wastes.

Bulky items are large worn-out or broken household, commercial, and industrial items such as furniture, lamps, bookcases, filing cabinets, and other similar items. *Consumer electronics* includes worn-out, broken, and other no-longer-wanted items such as radios, stereos, and television sets. *White goods* are large worn-out or broken household, commercial, and industrial appliances such as stoves, refrigerators, dishwashers, and clothes washers and dryers. Collected separately, white goods are usually dismantled for the recovery of specific materials (e.g., copper, aluminum, etc.).

The principal sources of batteries are from households and automobile and other vehicle servicing facilities. Household batteries come in a variety of types, including alkaline, mercury, silver, zinc, nickel, and cadmium. The metals found in household batteries can cause groundwater contamination by their presence in leachate; they can also contaminate air emissions and ash from waste combustion facilities. Many states now prohibit the landfilling of household batteries. Automobiles use lead-acid batteries, each of which contains approximately 18 pounds of lead and a gallon of sulfuric acid, both hazardous materials.

The principal source of used oil is from the servicing of automobiles and other moving vehicles by their owners. Waste oil, not collected for recycling, is often poured onto the ground; down sanitary, combined, and storm water sewers; or into trash containers. Waste oil discharged onto the ground or into municipal sewers often contaminates surface water and groundwater as well as the soil. Waste oil placed in the same container as other solid waste components tends to contaminate the waste components and thus reduces their value as recycled materials.

Somewhere between 230 and 240 million rubber tires are disposed of annually in landfills or in tire stockpiles. Because tires do not compact well, their disposal in landfills is expensive and wasteful of space. Stockpiling of tires also poses serious aesthetic as well as environmental problems. Large, difficult-to-extinguish fires have occurred in a number of stockpiles. In addition, stockpiled tires form an ideal breeding place for mosquitos.

Hazardous Wastes. Wastes or combinations of wastes that pose a substantial present or potential hazard to human health or living organisms have been defined as hazardous wastes. The U.S. EPA has defined RCRA hazardous wastes in three general categories: (1) listed wastes, (2) characteristic hazardous wastes, and (3) other hazardous wastes. Hazardous wastes found in MSW are considered further in Chapter 5.

Institutional

Institutional sources of solid waste include government centers, schools, prisons, and hospitals. Excluding manufacturing wastes from prisons and medical wastes

from hospitals, the solid wastes generated at these facilities are quite similar to commingled MSW. In most hospitals medical wastes are handled and processed separately from other solid wastes.

Construction and Demolition

Wastes from the construction, remodeling, and repairing of individual residences, commercial buildings, and other structures are classified as *construction wastes*. The quantities produced are difficult to estimate. The composition is variable but may include dirt; stones; concrete; bricks; plaster; lumber; shingles; and plumbing, heating, and electrical parts. Wastes from razed buildings, broken-out streets, sidewalks, bridges, and other structures are classified as *demolition wastes*. The composition of demolition wastes is similar to construction wastes, but may include broken glass, plastics, and reinforcing steel.

Municipal Services

Other community wastes, resulting from the operation and maintenance of municipal facilities and the provision of other municipal services, include street sweepings, road side litter, wastes from municipal litter containers, landscape and tree trimmings, catch-basin debris, dead animals, and abandoned vehicles. Because it is impossible to predict where dead animals and abandoned automobiles will be found, these wastes are often identified as originating from nonspecific diffuse sources. Wastes from nonspecific diffuse sources can be contrasted to that of the residential sources, which are also diffuse but specific in that the generation of the wastes is a recurring event.

Treatment Plant Wastes and Other Residues

The solid and semisolid wastes from water, wastewater, and industrial waste treatment facilities are termed *treatment plant wastes*. The specific characteristics of these materials vary, depending on the nature of the treatment process. At present, their collection is not the charge of most municipal agencies responsible for solid waste management. However, wastewater treatment plant sludges are commonly co-disposed with MSW in municipal landfills. In the future, the disposal of treatment plant sludges will likely become a major factor in any solid waste management plan.

Materials remaining from the combustion of wood, coal, coke, and other combustible wastes are categorized as *ashes and residues*. (Residues from power plants normally are not included in this category because they are handled and processed separately.) These residues are normally composed of fine, powdery materials, cinders, clinkers, and small amounts of burned and partially burned materials. Glass, crockery, and various metals are also found in the residues from municipal incinerators.

Industrial Solid Waste Excluding Process Wastes

Sources and types of solid waste generated at industrial sites, grouped according to their Standard Industrial Classification (SIC), are reported in Table 3-2 on pages 46 and 47. This list excludes industrial process wastes and any hazardous wastes that may be generated.

Agricultural Wastes

Wastes and residues resulting from diverse agricultural activities—such as the planting and harvesting of row, field, tree and vine crops; the production of milk; the production of animals for slaughter; and the operation of feedlots—are collectively called *agricultural wastes*. At present, the disposal of these wastes is not the responsibility of most municipal and county solid waste management agencies. However, in many areas the disposal of animal manure has become a critical problem, especially from feedlots and dairies.

3-3 COMPOSITION OF SOLID WASTES

Composition is the term used to describe the individual components that make up a solid waste stream and their relative distribution, usually based on percent by weight. Information on the composition of solid wastes is important in evaluating equipment needs, systems, and management programs and plans. For example, if the solid wastes generated at a commercial facility consist of only paper products, the use of special processing equipment, such as shredders and balers, may be appropriate. Separate collection may also be considered if the city or collection agency is involved in a paper-products recycling program. The potential for significant changes in composition in the future is considered at the end of this chapter.

Composition of MSW

The total solid wastes from a community are composed of the waste materials identified in Table 3-1. Typical data on the distribution of MSW are presented in Table 3-3. As noted in Table 3-3, the residential and commercial portion makes up about 50 to 75 percent of the total MSW generated in a community. The actual percentage distribution will depend on (1) the extent of the construction and demolition activities, (2) the extent of the municipal services provided, and (3) the types of water and wastewater treatment processes that are used. The wide variation in the special wastes category (3 to 12 percent) is due to the fact that in many communities yard wastes are collected separately. The percentage of construction and demolition wastes varies widely depending on the part of the country and the general health of the local, state, and national economy. The

TABLE 3-2
Sources and types of industrial wastes[a]

Code	SIC group classification[b]	Waste-generating processes	Expected specific wastes
19	Ordnance and accessories	Manufacturing and assembling	Metals, plastic, rubber, paper, wood, cloth, chemical residues
20	Food and kindred products	Processing, packaging, shipping	Meats, fats, oils, bones, offal, vegetables, fruits, nuts and shells, cereals
22	Textile mill products	Weaving, processing, dyeing, and shipping	Cloth and fiber residues
23	Apparel and other finished products	Cutting, sewing, sizing, pressing	Cloth, fibers, metals, plastics, rubber
24	Lumber and wood products	Sawmills, millwork plants, wooden container, miscellaneous wood products, manufacturing	Scrap wood, shaving, sawdust; in some instances metals, plastics, fibers, glues, sealers, paints, solvents
25a	Furniture, wood	Manufacture of household and office furniture, partitions, office and store fixtures, mattresses	Those listed under code 24; in addition, cloth and padding residues
25b	Furniture, metal	Manufacture of household and office furniture, lockers, bed-springs, frames	Metals, plastics, resins, glass, wood, rubber, adhesives, cloth, paper
26	Paper and allied products	Paper manufacture, conversion of paper and paperboard, manufacture of paperboard boxes and containers	Paper and fiber residues, chemicals, paper coatings and fillers, inks, glues, fasteners
27	Printing and publishing	Newspaper publishing, printing, lithography, engraving, and bookbinding	Paper, newsprint, cardboard, metals, chemicals, cloth, inks, glues
28	Chemical and related products	Manufacture and preparation of inorganic chemicals (ranges from drugs and soaps to paints and varnishes, and explosives)	Organic and inorganic chemicals, metals, plastics, rubber, glass, oils, paints, solvents, pigments
29	Petroleum refining and related industries	Manufacture of paving and roofing materials	Asphalt and tars, felts, asbestos, paper, cloth, fiber
30	Rubber and miscellaneous plastic products	Manufacture of fabricated rubber and plastic products	Scrap rubber and plastics, lampblack, curing compounds, dyes
31	Leather and leather products	Leather tanning and finishing; manufacture of leather belting and packing	Scrap leather, thread, dyes, oils, processing and curing compounds

32	Stone, clay, and glass products	Manufacture of flat glass, fabrication and forming of glass; manufacture of concrete, gypsum, and plaster products; forming and processing of stone and stone products, abrasives, asbestos, and miscellaneous non-mineral products	Glass, cement; clay, ceramics, gypsum, asbestos, stone, paper, abrasives
33	Primary metal industries	Melting, casting, forging, drawing, rolling, forming, extruding operations	Ferrous and nonferrous metals scrap, slag, sand, cores, patterns, bonding agents
34	Fabricated metal products	Manufacture of metal cans, hand tools, general hardware, nonelectric heating apparatus, plumbing fixtures, fabricated structural products, wire, farm machinery and equipment, coating and engraving of metal	Metals, ceramics, sand, slag, scale, coatings, solvents, lubricants, pickling liquor
35	Machinery (except electrical)	Manufacture of equipment for construction, mining, elevators, moving stairways, conveyors, industrial trucks, trailers, stackers, machine tools, etc.	Slag, sand, cores, metal scrap, wood, plastics, resins, rubber, cloth, paints, solvents, petroleum products
36	Electrical	Manufacture of electric equipment, appliances, and communication apparatus; machining, drawing, forming, welding, stamping, winding, painting, planting, baking, firing operations	Metal scrap, carbon black, glass, exotic metals, rubber, plastics, resins, fibers, cloth residues
37	Transportation equipment	Manufacture of motor vehicles, truck and bus bodies, motor vehicle parts and accessories, aircraft and parts, ship and boat building and repairing, motorcycles and bicycles and parts, etc.	Metal scrap, glass, fiber, wood, rubber, plastics, cloth, paints, solvents, petroleum products
38	Professional, scientific controlling instruments	Manufacture of engineering, laboratory and research instruments and associated equipment	Metals, plastics, resins, glass, wood, rubber, fibers, abrasives
39	Miscellaneous manufacturing	Manufacture of jewelry, silverware, plated ware, toys, amusement, sporting and athletic goods, costume novelties, buttons, brooms, brushes, signs, advertising displays	Metals, glass, plastics, resins, leather, rubber, bone, cloth, straw, adhesives, paints, solvents, composite materials

[a] Adapted in part from Ref. 8.

[b] *Source:* Standard Industrial Classification Manual (SIC) 1972, Executive Office of the President, Office of Management and Budget, U.S. Government Printing Office, Washington, DC.

TABLE 3-3
Estimated distribution of all components of MSW generated in a typical community excluding industrial and agricultural wastes[a]

Waste category[b]	Percent by weight	
	Range	Typical
Residential and commercial, excluding special and hazardous wastes	50–75	62.0
Special (bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires)	3–12	5.0
Hazardous[c]	0.01–1.0	0.1
Institutional	3–5	3.4
Construction and demolition	8–20	14.0
Municipal services		
Street and alley cleanings	2–5	3.8
Tree and landscaping	2–5	3.0
Parks and recreational areas	1.5–3	2.0
Catch basin	0.5–1.2	0.7
Treatment plant sludges	3–8	6.0
Total		100.0

[a] Adapted in part from Refs. 9, 14–16.

[b] See Table 6-3 for estimated quantities of waste generated.

[c] Range of reported values varies widely depending on method used to identify and classify hazardous wastes found in MSW.

percentage of treatment plant sludges will also vary widely depending on the extent and type of water and wastewater treatment provided.

Distribution of Individual Waste Components

Information and data on the physical composition of solid wastes are important in the selection and operation of equipment and facilities (see Chapters 6 through 10), in assessing the feasibility of resource and energy recovery (see Chapter 9), and in the analysis and design of landfill disposal facilities (see Chapter 11). Published distribution data should be used cautiously because the effects of recycling activities and the use of kitchen food waste grinders are often not reflected in earlier data.

Residential Portion of MSW in the United States. Components that typically make up the residential portion of MSW, excluding special and hazardous wastes, and their relative distribution are reported in Table 3-4. Although any number of components could be selected, those in Table 3-4 have been selected because they are readily identifiable and consistent with component categories reported in the literature and because they have proven adequate for the characterization

TABLE 3-4
Typical physical composition of residential MSW excluding recycled materials and food wastes discharged with wastewater (1990)

	Percent by weight			
	United States[a]			
Component	Range	Typical[b]	Packaging materials[c]	Davis, California[d]
Organic				
Food wastes	6–18	9.0	—	6.0
Paper	25–40	34.0	50–60	33.1
Cardboard	3–10	6.0		7.9
Plastics	4–10	7.0	12–16	10.7
Textiles	0–4	2.0	—	2.4
Rubber	0–2	0.5	—	2.5
Leather	0–2	0.5	—	0.1
Yard wastes	5–20	18.5	—	17.7
Wood	1–4	2.0	4–8	5.0
Misc. organics	—	—	—	0.4
Inorganic				
Glass	4–12	8.0	20–30	5.8
Tin cans	2–8	6.0	6–8	3.9
Aluminum	0–1	0.5	2–4	0.4
Other metal	1–4	3.0	—	3.6
Dirt, ash, etc.	0–6	3.0	—	0.5
Total		100.0		100.0

[a] Adapted in part from Refs. 2, 3, 9, and 14–16. Reported percentage distributions are exclusive of special and hazardous wastes.

[b] Twenty percent of the households in the United States are assumed to have food waste grinders. Additionally, it is assumed that the percentage of food waste ground up and discharged with wastewater is 25 percent. Current (1990) recycling rate for the United States assumed to be 11 percent.

[c] Adapted in part from Ref. 10.

[d] Based on measurements made over a five-year period (1985 to 1990) during the first two weeks of October (see Table 3-9).

of solid wastes for most applications. The data in Table 3-4 are derived from both the literature and the authors' experience. For the purpose of comparison, the percentage distribution of the materials used for packaging is reported in Column 3 of Table 3-4. It is estimated that packaging wastes now account for approximately one-third of the residential and commercial MSW [10].

The values given in Table 3-4 for food waste, plastics, and yard wastes are considerably different from the values given in the corresponding table (Table 4-2) in the predecessor of this text, published in 1977 [12]. The differences are due largely to (1) improved food processing techniques and the increased use of kitchen food waste grinders, (2) the increased use of plastics for food packaging and other packaging, and (3) the fact that burning of yard wastes is no longer allowed in most communities.

TABLE 3-5
Typical distribution of components in residential MSW for low-, middle-, and upper-income countries excluding recycled materials[a,b]

Component	Low-income countries	Middle-income countries	Upper-income countries[c]
Organic			
Food wastes	40–85[d]	20–65	6–30
Paper	1–10	8–30	20–45
Cardboard			5–15
Plastics	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	1–5	1–10	10–20
Wood			1–4
Misc. organics	—	—	—
Inorganic			
Glass	1–10	1–10	4–12
Tin cans			2–8
Aluminum	1–5	1–5	0–1
Other metal			1–4
Dirt, ash, etc.	1–40	1–30	0–10

[a] Adapted in part from Refs. 1 and 17.

[b] Low-income countries: per capita income of less than U.S. $750 in 1990.
Middle-income countries: per capita income of more than U.S. $750 and less than U.S. $5000 in 1990.
Upper-income countries: per capita income of more than U.S. $5000 in 1990.

[c] Upper-income countries are more highly industrialized.

[d] Food wastes composed predominantly of waste from the preparation of food (corn husks, melon rinds, banana leaves, etc.).

Residential Portion of MSW in Other Countries. For the purposes of comparison, typical data on the distribution of the components in residential MSW from other countries are presented in Table 3-5. In comparing the data presented in Tables 3-5 and 3-6, note the high percentage of food waste in less-developed countries. The percentage of food wastes is high because most vegetables and fruits are not pre-trimmed, there are essentially no kitchen food waste grinders, and the amounts of the other components are quite small.

Industrial Solid Wastes Excluding Process Wastes. Data on the percentage distribution of the wastes generated from the industrial activities given in Table 3-2 are presented in Table 3-6. A range of values is given for each waste component category, because industrial operations tend to be quite variable.

Effect of Waste Diversions on Distribution of Components in Residential MSW

To assess the impact of waste diversions (resulting from the use of food waste grinders and waste recycling programs) on the distribution of waste components,

TABLE 3-6
Typical data on the distribution of solid wastes generated by major industries excluding recycled materials and industrial process wastes[a]

SIC Code		Percent by weight									
		Food wastes[b]	Paper	Wood	Leather	Rubber	Plastics	Metals	Glass	Textiles	Misc.
20	Food and kindred products	15–20	50–60	5–10	0–2	0–2	0–5	5–10	4–10	0–2	5–15
22	Textile mill products	0–2	40–50	0–2	0–2	0–2	3–10	0–2	0–2	20–40	0–5
23	Apparel and other finished products	0–2	40–60	0–2	0–2	0–2	0–2	0–2	0–2	30–50	0–5
24	Lumber and wood products	0–2	10–20	60–80	0–2	0–2	0–2	0–2	0–2	0–2	5–10
25a	Furniture, wood	0–2	20–30	30–50	0–2	0–2	0–2	0–2	0–2	0–5	0–5
25b	Furniture, metal	0–2	20–40	10–20	0–2	0–2	0–2	20–40	0–2	0–5	0–10
26	Paper and allied products	0–2	40–60	10–15	0–2	0–2	0–2	5–15	0–2	0–2	10–20
27	Printing and publishing	0–2	60–90	5–10	0–2	0–2	0–2	0–2	0–2	0–2	0–5
28	Chemicals and related products	0–2	40–60	2–10	0–2	0–2	5–15	5–10	0–5	0–2	15–25
29	Petroleum refining and related industries	0–2	60–80	5–15	0–2	0–2	10–20	2–10	0–2	0–2	2–10
30	Rubber and miscellaneous plastic products	0–2	40–60	2–10	0–2	5–20	10–20	0–2	0–2	0–2	0–5
31	Leather and leather products	0–2	5–10	5–10	40–60	0–2	0–2	10–20	0–2	0–2	0–5
32	Stone, clay, and glass products	0–2	20–40	2–10	0–2	0–2	0–2	5–10	10–20	0–2	30–50
33	Primary metal industries	0–2	30–50	5–15	0–2	0–2	2–10	2–10	0–5	0–2	20–40
34	Fabricated metal products	0–2	30–50	5–15	0–2	0–2	0–2	15–30	0–2	0–2	5–15
35	Machinery (except electrical)	0–2	30–50	5–15	0–2	0–2	1–5	15–30	0–2	0–2	0–5
36	Electrical	0–2	60–80	5–15	0–2	0–2	2–5	2–5	0–2	0–2	0–5
37	Transportation equipment	0–2	40–60	5–15	0–2	0–2	2–5	0–2	0–2	0–2	15–30
38	Professional scientific controlling instruments	0–2	30–50	2–10	0–2	0–2	5–10	5–15	0–2	0–2	0–5
39	Miscellaneous manufacturers	0–2	40–60	10–20	0–2	0–2	5–15	2–10	0–2	0–2	5–15

[a] From Ref. 13.

[b] With the exception of food and kindred products, food wastes are from company cafeterias, canteens, etc.

the distribution given in Table 3-4 for *as collected* residential MSW must be adjusted. The methodology used to adjust the waste component distribution is illustrated in Example 3-1. The adjusted component distribution data are reported in Table 3-7. As shown in Table 3-7, the distribution data for the United States do not change significantly. On the other hand, the distribution data for the city of Davis, California, would change quite a bit more because of the higher percentage of recycling.

TABLE 3-7
Typical physical composition of residential MSW in the United States in 1990[a]

Component	Percent by weight			
	Solid waste *as collected* excluding waste components now recycled and food waste that is ground up[b]	Solid waste *as collected* plus ground up food waste, but excluding waste components now recycled[c]	Solid waste *as collected* plus waste components now recycled excluding food waste that is ground up[d]	Solid waste *as collected* plus waste components now recycled and food waste that is ground up[e]
Organic				
Food wastes	9.0	9.4	8.0	8.4
Paper	34.0	33.8	35.8	35.6
Cardboard	6.0	6.0	6.4	6.4
Plastics	7.0	7.0	6.9	6.9
Textiles	2.0	2.0	1.8	1.8
Rubber	0.5	0.5	0.4	0.4
Leather	0.5	0.5	0.4	0.4
Yard wastes	18.5	18.4	17.3	17.2
Wood	2.0	2.0	1.8	1.8
Misc. organics	—	—	—	—
Inorganic				
Glass	8.0	7.9	9.1	9.0
Tin cans	6.0	6.0	5.8	5.8
Aluminum	0.5	0.5	0.6	0.6
Other metal	3.0	3.0	3.0	3.0
Dirt, ash, etc.	3.0	3.0	2.7	2.7
Total	100.0	100.0	100.0	100.0

[a] Procedure used to compute the values in this table is delineated in Example 3-1.

[b] From Table 3-4.

[c] Twenty percent of the households in the United States are assumed to have food waste grinders. Additionally, it is assumed that the percentage of food waste ground up and discharged with wastewater is 25 percent.

[d] Current (1990) recycling rate for the United States assumed to be 11 percent.

[e] Column 5 represents the percentage distribution of the total amount of residential MSW now generated, including the waste components that are now recycled and the food wastes that are ground up and discharged to the sewer.

Example 3-1 Impact of food waste grinders and waste recycling on the distribution of waste components in residential MSW. Assess the impact of the use of food waste grinders and waste recycling on the percentage distribution of the components found in residential MSW. Assume the following data apply:

1. Use of waste food grinders
   (*a*) Households in the United States that have food waste grinders = 20%
   (*b*) Percentage of the total amount of food waste that is ground up and discharged to the local sewer = 25%
2. Waste recycling
   (*a*) Percentage of the total amount of residential MSW that is now recycled, excluding food waste that is ground up = 11%
   (*b*) Percentage distribution by weight of waste components now recycled and not included in *as collected* waste distribution.

Paper = 50%
Cardboard = 10%
Plastic = 6%
Yard wastes = 8%
Tin cans = 4%
Glass = 18%
Aluminum = 1%
Nonferrous metal = 3%

Solution

1. Estimate the amount of food waste that is now ground up.
   (*a*) To account for the food wastes that are now ground up and discharged to the local sewer, the original weight of food wastes must be adjusted as follows:

$$\text{FW}_a,\ \text{lb} = \frac{\text{FW}}{[H_{w/o} + H_w(1 - \text{fw}_g)]}$$

where FW_a = adjusted food waste (accounts for food waste that is now ground up and discharged to sewer)
FW = food waste in "as collected MSW," lb (based on 100-lb sample of waste—see column 3 in Table 3-4)
$H_{w/o}$ = fraction of homes without food waste grinders
H_w = fraction of homes with food waste grinders
fw_g = fraction of food waste that is ground up

   (*b*) Compute the adjusted food waste value using the above expression and the given data.

$$\text{FW}_a, \text{lb} = \frac{9.0}{0.80 + 0.20(1 - 0.25)} = 9.5$$

2. Set up a computation table to determine the percentage distribution of the waste components given in Table 3-4 taking into account the amount of food waste that is now

ground up (0.5 lb = 9.5 lb − 9.0 lb). The new distribution given in the following table (column 3) is obtained by adding 0.5 lb to the food waste and dividing all of the component weights by the new total weight 100.5 lb (100 lb + 0.5 lb).

	Percent by weight	
Component	Solid waste as collected	Solid waste as collected plus ground up food waste
Organic		
Food wastes	9.0 (9.5)	9.4
Paper	34.0	33.8
Cardboard	6.0	6.0
Plastics	7.0	7.0
Textiles	2.0	2.0
Rubber	0.5	0.5
Leather	0.5	0.5
Yard wastes	18.5	18.4
Wood	2.0	2.0
Misc. organics	—	—
Inorganic		
Glass	8.0	7.9
Tin cans	6.0	6.0
Aluminum	0.5	0.5
Other metal	3.0	3.0
Dirt, ash, etc	3.0	3.0
Total	100.0 (100.5)	100.0

[a] From Table 3-4.

3. Set up a computation table to determine the percentage distribution of the waste components given in Table 3-4 taking into account the amount of waste that is recycled and the food wastes that are now ground up and discharged to the sewer. The required computation table follows on page 55.

   (*a*) The percentage distribution of solid waste as collected is given in column 2.

   (*b*) The percentage distribution of the solid waste materials that are now recycled separately from the *as collected* waste is given in column 3.

   (*c*) The actual weight of material that is now recycled separately from the *as collected* waste, based on 11 percent of the total weight of solid waste (i.e., 11 lb out of 100 lb) is given in column 4.

   (*d*) The actual weight of material that is now collected, based on 89 percent of the total weight of solid waste (i.e., 89 lb) is given in column 5. The actual values given in column 5 are obtained by multiplying the distribution percentage values given in column 2 by 89 lb.

   (*e*) The percentage distribution of the solid waste as collected plus the recycled materials is given in column 6. The values reported in column 6 are obtained by summing the values in columns 4 and 5.

Component (1)	Percent by weight: Solid waste *as collected* excluding recycled waste components and ground up food waste[a] (2)	Percent by weight: Solid waste components now recycled (not reflected in *as collected* distribution) (3)	Weight of solid waste components now recycled (11 lb based on a total of 100 lb excluding ground up food waste), lb[b] (4)	Solid waste *as collected* excluding waste now recycled (89 lb based on a total 100 lb excluding ground up food waste), lb[c] (5)	Percent by weight: Solid waste *as collected* plus recycled wastes[b] (6) = (4) + (5)	Percent by weight: Solid waste *as collected* plus recycled and ground up food waste[d] (7)
Organic						
Food wastes	9.0	0.0	0.00	8.01	8.0	8.4
Paper	34.0	50.0	5.50	30.26	35.8	35.6
Cardboard	6.0	10.0	1.10	5.34	6.4	6.4
Plastics	7.0	6.0	0.66	6.23	6.9	6.9
Textiles	2.0	0.0	0.00	1.78	1.8	1.8
Rubber	0.5	0.0	0.00	0.45	0.4	0.4
Leather	0.5	0.0	0.00	0.45	0.4	0.4
Yard wastes	18.5	8.0	0.88	16.46	17.3	17.2
Wood	2.0	0.0	0.00	1.78	1.8	1.8
Misc. organics	—	—	—	—	—	—
Inorganic						
Glass	8.0	18.0	1.98	7.12	9.1	9.0
Tin cans	6.0	4.0	0.44	5.34	5.8	5.8
Aluminum	0.5	1.0	0.11	0.44	0.6	0.6
Other metal	3.0	3.0	0.33	2.67	3.0	3.0
Dirt, ash, etc.	3.0	0.0	0.00	2.67	2.7	2.7
Total	100.0	100.0	11.00[b]	89.00	100.0	100.0

[a] From Table 3-4.

[b] Amount now recycled = 11 percent or 11 lb based on 100 lb.

[c] 89.0 lb = 100 lb − 11 lb (amount now recycled).

[d] Column 7 represents the percentage distribution of the total amount of waste generated including the waste components that are now recycled and the food wastes that are ground up.

(*f*) The percentage distribution of the solid waste as collected plus recycled materials and ground up food waste is given in column 7. The adjusted value for food wastes, computed using the expression given in Step 1 is:

$$FW_a, \text{lb} = \frac{8.0}{0.80 + 0.20(1 - 0.25)} = 8.4$$

The distribution values given in column 7 are obtained by adding 0.4 lb to the food waste in column 6 and dividing all of the component percentages in column 6, expressed as lb, by the new total weight of 100.4 lb (100 lb + 0.4 lb).

Comment. The computational approach used in this example can be used to determine the percentage distribution values for any level of recycling. This approach will be especially important in determining the percentage of wastes diverted from landfills.

Variation in the Percentage Distribution of Waste Components

The percentage distribution values for the components in MSW vary with location, season, economic conditions, and many other factors. Typical seasonal variations in waste quantities are presented in Table 3-8. Because variations are known to occur, if the distribution of components is a critical factor in a particular management decision process, a special study should be undertaken if possible to assess the actual distribution. Even then, it may still be impossible to obtain an accurate assessment unless a prohibitively large number of samples are analyzed. In general, the coefficient of variation (CV) (see Appendix D) for the individual waste constituents is quite large. Typical CV values for paper in residential MSW range from about 20 to 40 percent. For the remaining components in the waste stream, CV values can vary from 40 to 100 percent. Data collected during October for the city of Davis, CA, over a 20-year period are reported in Table 3-9.

TABLE 3-8
Typical seasonal variation observed in the *as collected* composition of residential MSW[a]

	Percent by weight		Percent variation[b]	
Waste	Winter season	Summer season	Decrease	Increase
Food waste	11.1	13.5		21.6
Paper	45.2	40.0	11.5	
Plastics	9.1	8.2	9.9	
Other organics	4.0	4.6		15.0
Yard wastes	18.7	24.0		28.3
Glass	3.5	2.5	28.6	
Metals	4.1	3.1	24.4	
Inert and other waste	4.3	4.1	4.7	
Total	100.0	100.0		

[a] Adapted from Ref. 11.

[b] Based on winter season.

TABLE 3-9

Typical composition of residential MSW from Davis, CA, excluding recycled materials and food wastes discharged to sewers. All data collected during the first two weeks of October. The community of Davis also has separate collection of yard wastes.

	Percent by weight															
Component	**1971**	**1972**	**1973**	**1974**	**1975**	**1977**	**1978**	**1979**	**1981**	**1982**	**1984**	**1986**	**1987**	**1988**	**1989**	**1990**
Organic																
Food wastes	13.5	5.5	19.6	7.5	7.7	7.9	9.8	11.9	5.2	5.0	16.0	6.8	6.5	5.8	3.4	7.6
Paper	33.4	31.8	29.5	43.6	32.8	39.1	28.9	41.3	36.9	42.9	22.7	35.9	32.2	29.1	33.9	34.1
Cardboard	14.2	10.4	23.0	7.8	15.0	8.0	12.3	3.4	15.2	11.0	10.5	8.9	6.8	8.2	6.6	8.9
Plastics	3.1	4.0	3.9	1.8	5.2	5.6	6.7	5.2	7.6	8.1	11.4	8.2	10.0	10.6	12.8	11.8
Textiles	3.9	1.9	0.2	0.1	2.3	1.1	1.5	1.8	6.2	9.2	7.8	1.9	3.6	1.9	2.5	1.9
Rubber	1.3	1.6	Trace	1.4	0.8	0.9	1.2	5.2	3.2	1.7	1.0	1.9	2.8	0.7	4.7	2.4
Leather					0.3		0.1	0.7	—	—	—	—	—	0.3	—	0.1
Yard wastes	1.0	24.3	10.8	14.1	14.4	14.6	17.7	9.9	4.9	4.8	8.1	17.6	20.0	21.4	13.1	16.5
Wood	2.3	2.6	0.9	4.2	1.6	0.8	0.8	0.7	3.6	1.6	4.3	4.6	4.2	5.9	8.0	2.2
Misc. organics	2.0	—	—	—	—	—	3.1	1.6	—	1.5	0.5	—	—	2.2	—	—
Inorganic																
Glass	13.0	8.2	6.4	7.7	6.4	11.7	10.4	5.7	6.0	5.0	9.2	7.0	6.6	6.3	3.2	6.1
Tin cans	6.1	6.6	1.9	1.8	6.7	4.8	5.2	7.8	4.1	3.5	3.1	3.7	4.3	3.6	4.4	3.6
Aluminum cans	0.2	—	0.5	1.4	1.2	1.0	1.5	2.3	1.2	1.4	0.8	0.5	0.5	0.5	0.2	0.3
Other metal	5.8	—	2.6	7.6	5.0	0.5	0.7	—	5.2	4.3	1.6	2.2	2.5	3.5	6.2	3.7
Dirt, ashes, etc.	0.2	1.2	0.7	1.0	0.6	4.6	0.1	2.5	0.7	—	3.0	0.8	—	—	1.0	0.8

A common failing in many engineering studies is to spend far too much money collecting data that are of limited value or may never be used. This situation is often true with regard to the collection of statistical distribution data on solid waste components during one sampling period. For example, it is usually more important to have information on the seasonal variation of waste generation rates (e.g., Table 3-8) than to know whether the percentage of a given component is 8.1 versus 8.12 during any one sampling period. In the conduct of waste characterization studies, the distribution of components presented in Table 3-7 may be used as a guide in assessing the reasonableness of the findings.

3-4 DETERMINATION OF THE COMPOSITION OF MSW IN THE FIELD

Because of the heterogeneous nature of solid wastes, determination of the composition is not an easy task. Strict statistical procedures are difficult, if not impossible, to implement. For this reason, more generalized field procedures, based on common sense and random sampling techniques, have evolved for determining composition.

Residential MSW

The procedure for residential MSW involves unloading and analyzing a quantity of residential waste in a controlled area of a disposal site that is isolated from winds and separate from other operations. A representative residential sample might be a truckload resulting from a typical weekday collection route in a residential area. A mixed sample from an incinerator storage pit or the discharge pit of a shredder would also be representative. Common sense is important in selecting the load to be sampled. For example, a load containing the weekly accumulation of yard wastes (leaves) during autumn would not be typical. To ensure that the results obtained are representative, a large enough sample must be examined. It has been found that measurements made on a sample size of about 200 lb vary insignificantly from measurements made on samples of up to 1700 lb taken from the same waste load [5, 7]. The authors have obtained similar results in field studies performed in Hawaii and at Davis, California.

To obtain a sample for analysis, the load is first quartered. One part is then selected for additional quartering until a sample size of about 200 lb is obtained. It is important to maintain the integrity of each selected quarter, regardless of the odor or physical decay, and to make sure that all the components are measured (see Fig. 3-2). Only in this way can some degree of randomness and unbiased selection be maintained. (Additional information on sampling procedures is presented in Section 6-7 in Chapter 6.)

Commercial and Industrial MSW

The field procedure for component identification for commercial and nonprocess industrial solid wastes involves the analysis of representative waste samples taken directly from the source, not from a mixed waste load in a collection vehicle.

(*a*)

(*b*)

FIGURE 3-2
Determination of the percentage distribution of waste components in the field: (*a*) separated waste materials placed in separate containers to be weighed and (*b*) weighing of the wastes using a platform scale. (Courtesy of Brown and Caldwell, Consultants.)

Because commercial and industrial sources are so variable, statistically valid sampling is seldom possible. Estimation of the distribution of waste components and quantities for these activities remains an art form.

3-5 TYPES OF MATERIALS RECOVERED FROM MSW

The purpose of this section is to identify the types of materials that are now separated from MSW for recycling and introduces and discusses briefly the importance of materials specifications in the processing and marketing of recovered materials. Knowledge of the waste materials that are now recovered for reuse and recycling is important in the conduct of waste generation and diversion studies.

Materials Commonly Separated from MSW

Materials that are now (1992) separated for recycling are reported in Table 3-10. The most common ones from MSW are aluminum, paper, plastics, glass, ferrous metal, nonferrous metal, yard wastes, and construction and demolition wastes (see Fig. 3-3). Each is considered briefly in the following discussion. Other materials recovered from residential and commercial MSW as identified in Table 3-10 are considered in Chapter 15, where the actual recycling of these materials is considered in greater detail.

Aluminum. Aluminum recycling is made up of two sectors: aluminum cans and secondary aluminum. Secondary aluminum includes window frames, storm doors, siding, and gutters. Because secondary materials are of different grades, specifications for recycled aluminum should be checked, to recover the maximum value when selling separated materials to brokers. The demand for recycled aluminum cans is high, as it takes 95 percent less energy to produce an aluminum can from an existing can than from ore.

Paper. The principal types of waste paper that are recycled are old newspaper, cardboard, high-grade paper, and mixed paper. Each of these four grades consists of individual grades, which are defined according to the type of fiber, source, homogeneity, extent of printing, and physical or chemical characteristics. High-grade paper includes office paper, reproduction paper, computer printout, and other grades having a high percentage of long fibers. Mixed grades include paper with high ground-wood content, such as magazines; coated paper; and individual grades containing excessive percentages of "outthrows" (papers of lower grades than the grade specified). The types of paper found in residential solid waste before the removal of newspapers or other papers for recycling are reported in Table 3-11.

Plastics. Plastics can be classified into two general categories: clean commercial grade scrap and post-consumer scrap. The two types of post-consumer plastics that are now most commonly recycled are polyethylene terephthalate (PETE/1), which is used for the manufacture of soft drink bottles, and high-density polyethylene (HDPE/2), used for milk and water containers and detergent bottles. In 1987, more than 150 million pounds of plastic soft drink bottles were recycled. Even so, less than five percent of the available scrap plastic is being recycled. It is anticipated that all of the other types of plastics will be recycled in greater quantities in the future, however, as processing technologies improve.

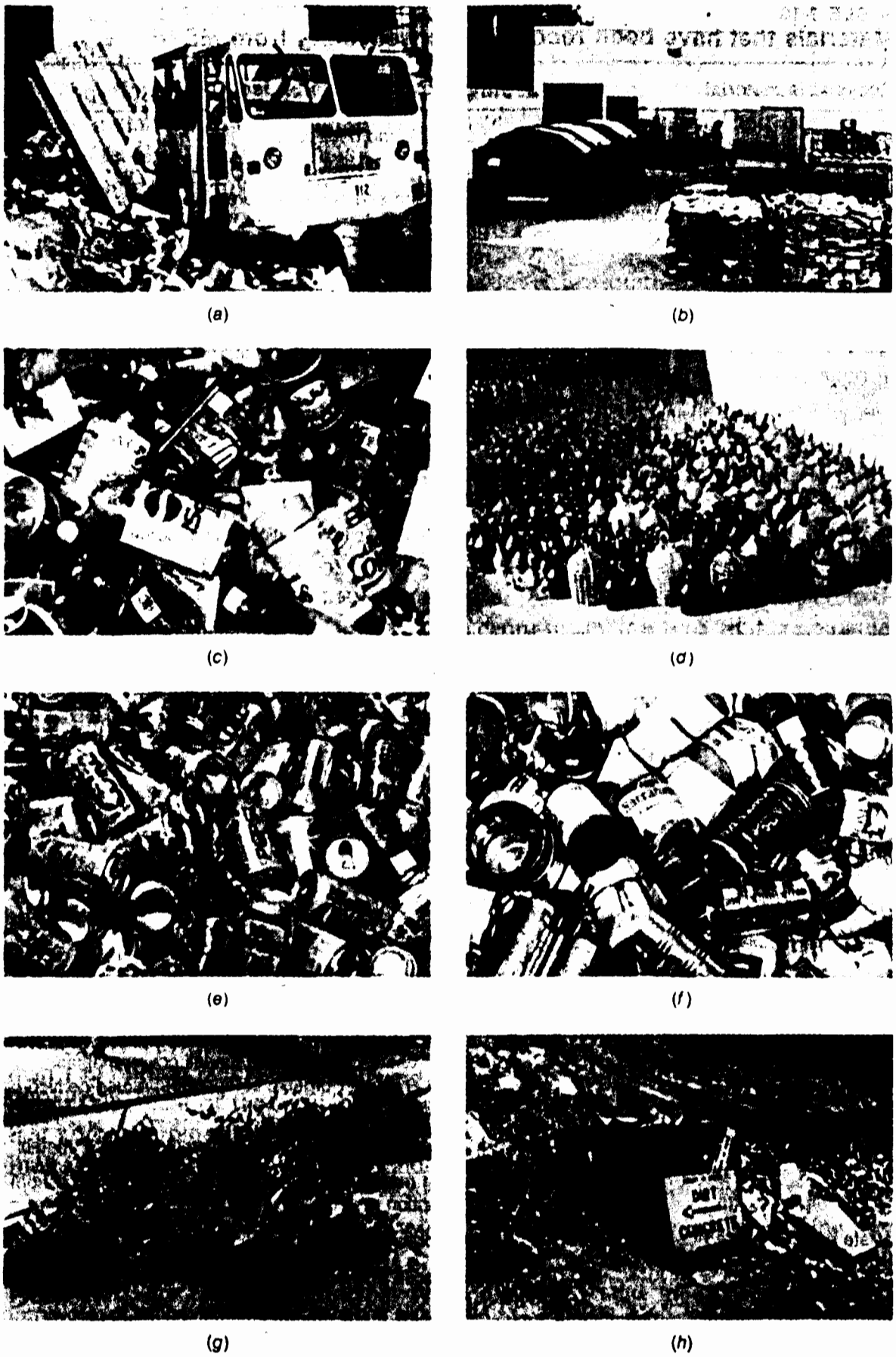
Glass. Glass is also a commonly recycled material. Container glass (for food and beverage packing), flat glass (e.g., window glass), and pressed or amber and green glass are the three principal types of glass found in MSW. Glass to be reprocessed is often separated by color into categories of clear, green, and amber.

Ferrous Metals (Iron and Steel). The largest amount of recycled steel has traditionally come from large items such as cars and appliances. Many communities

TABLE 3-10
Materials that have been recovered for recycling from MSW[a]

Recyclable material	Types of materials or uses
Aluminum	Soft drink and beer cans
Paper	
Old newspaper (ONP)	Newsstand and home-delivered newspaper
Corrugated cardboard	Bulk packaging; largest single source of waste paper for recycling
High-grade paper	Computer paper, white ledger paper, and trim cuttings
Mixed paper	Various mixtures of clean paper, including newsprint, magazines, and white and colored long-fiber paper
Plastics	
Polyethylene terephthalate (PETE/1)	Soft drink bottles, salad dressing and vegetable oil bottles; photographic film
High-density polyethylene (HDPE/2)	Milk jugs, water containers, detergent and cooking oil bottles
Polyvinyl chloride (PVC/3)	Home landscaping irrigation piping, some food packaging, and bottles
Low-density polyethylene (LDPE/4)	Thin-film packaging and wraps; dry cleaning film bags; other film material
Polypropylene (PP/5)	Closures and labels for bottles and containers, battery casings, bread and cheese wraps, cereal box liners
Polystyrene (PS/6)	Packaging for electronic and electrical components, foam cups, fast food containers, tableware and microwave plates
Multilayer and other (7)	Multilayered packaging, ketchup and mustard bottles
Mixed plastics	Various combinations of the above products
Glass	Clear, green, and brown glass bottles and containers
Ferrous metal	Tin cans, white goods, and other metals
Nonferrous metals	Aluminum, copper, lead, etc.
Yard wastes, collected separately	Used to prepare compost; biomass fuel; intermediate landfill cover
Organic fraction of MSW	Used to prepare compost for soil applications; compost for use as intermediate landfill cover; methane; ethanol and other organic compounds; refuse-derived fuel (RDF)
Construction and demolition wastes	Soil, asphalt, concrete, wood, drywall, shingles, metals
Wood	Packing materials, pallets, scraps, and used wood from construction projects
Waste oil	Automobile and truck oil; reprocessed for reuse or fuel
Tires	Automobile and truck tires; road building material; fuel
Lead-acid batteries	Automobile and truck batteries; shredded to recover individual components such as acid, plastic, and lead
Household batteries	Potential recovery of zinc, mercury, and silver

[a] Detailed information on the recycling opportunities for the individual materials may be found in Chapter 15.



(a) (b) (c) (d) (e) (f) (g) (h)

FIGURE 3-3
Commonly recycled waste materials: (*a*) paper, (*b*) cardboard, (*c*) plastics, (*d*) glass, (*e*) aluminum cans, (*f*) ferrous metals, (*g*) yard wastes, and (*h*) construction and demolition wastes.

TABLE 3-11
Percentage distribution of paper types found in residential solid waste[a]

	Percent by weight	
Type of paper	Range	Typical
Newspaper	10–20	17.7
Books and magazines	5–10	8.7
Commercial printing	4–8	6.4
Office paper	8–12	10.1
Other paperboard	8–12	10.1
Paper packaging	6–10	7.8
Other nonpackaging paper	8–12	10.6
Tissue paper and towels	6–8	5.9
Corrugated materials	20–25	22.7
Total		100.0

[a] Adapted from Refs. 4 and 16.

have large scrap metal piles at the local landfill or transfer station. In many cases, the piles are unorganized and different metals are mixed together, making them unattractive to scrap metal buyers. Steel can recycling is also becoming more popular. Steel cans, used as juice, soft drink, and food containers, are easily separated from mixed recyclables or municipal solid waste using large magnets (which also separate other ferrous metals).

Nonferrous Metals. Recyclable nonferrous metals are recovered from common household items (outdoor furniture, kitchen cookware and appliances, ladders, tools, hardware); from construction and demolition projects (copper wire, pipe and plumbing supplies, light fixtures, aluminum siding, gutters and downspouts, doors, windows); and from large consumer, commercial, and industrial products (appliances, automobiles, boats, trucks, aircraft, machinery). Virtually all nonferrous metals can be recycled if they are sorted and free of foreign materials such as plastics, fabrics, and rubber.

Yard Wastes Collected Separately. In most communities yard wastes are collected separately. The composting of yard wastes has become of great interest as cities and towns seek to find ways in which to achieve mandated diversion goals. Leaves, grass clippings, bush clippings, and brush are the most commonly composted yard wastes. Stumps and wood are also compostable, but only after they have been chipped to produce a smaller more uniform size. Composting of the organic fraction of MSW is also becoming more popular.

Construction and Demolition Wastes. In many locations construction and demolition (C&D) wastes are now being processed to recover marketable items such as wood chips for use as a fuel in biomass combustion facilities, aggregate for

concrete in construction projects, ferrous and nonferrous metals for remanufacture, and soil for use as fill material. The reprocessing of C&D wastes is gaining in popularity as disposal fees at landfills continue to increase. When disposal fees were below 5 dollars per ton (early 1970s), reprocessing was not economically feasible. Today (1992), with average landfill disposal fees approaching 60 dollars per ton in many parts of the country, the reprocessing of C&D wastes is economically feasible.

Specifications for Recovered Materials

As the amount of material recovered from MSW continues to increase as communities develop programs to meet waste diversion goals, materials specifications will become an important factor. In general, there is less contamination in source-separated material, but collection is more labor-intensive, and many communities are choosing to sort all materials at a central materials recovery facility (MRF). In many regions, markets for materials are not keeping pace with the volume collected, and it is expected that buyers will tighten specifications; as a result, vendors will no longer have assured markets, and will be competing to sell materials. As the specifications for recovered materials become more restrictive, recovery program managers must consider buyer specifications carefully when choosing collection and sorting systems, especially where large capital expenditures are involved.

3-6 FUTURE CHANGES IN WASTE COMPOSITION

In terms of solid waste management planning, knowledge of future trends in the composition of solid wastes is of great importance. For example, if a paper recycling program were instituted on the basis of current distribution data and if paper production were subsequently eliminated, such a program would more than likely become a costly white elephant. Although this case is extreme, it nevertheless illustrates the point that future trends must be assessed carefully in long-term planning. Another important question is whether the quantities are actually changing or only the reporting system has improved. Factors that affect the actual quantities of waste generated are considered in Chapter 6.

Impacts of Waste Diversion Programs

As more states adopt legislation mandating the development of source reduction and recycling programs, the composition of the wastes collected will change. The impact of waste diversion programs on the composition of the wastes collected will vary depending on the other types of waste management programs that are in place. For example, a solid waste combustion facility, developed to serve a commercial area, was planned and designed on the basis that the energy content of the waste would be 6500 Btu/lb. Six years later when the facility went on line, the actual energy content of the waste was 4500 Btu/lb, owing to the extensive

recycling of cardboard that had developed in the intervening years. To meet a contractual requirement to generate a firm amount of power, the number of truck loads of waste had to be increased, necessitating a change in the facility permit.

Future Changes in Waste Components

In planning for future waste management systems, it will be important to consider the changes that may occur in the composition of solid waste with time. Four waste components that have an important influence on the composition of the wastes collected are food waste, paper and cardboard, yard waste, and plastics. For the purposes of comparison, the classification of materials used to define municipal refuse in the early 1900s is given in Table 3-12. In comparing the entries in Table 3-12 with those in Table 3-1, public refuse corresponds to waste from municipal sources, trade and market refuse corresponds to wastes from commercial sources, and house refuse corresponds to waste from residential sources. Stable refuse has disappeared as a waste category in current classification systems, while plastics were nonexistent in the early 1900s.

Food Wastes. The quantity of residential food wastes collected has changed significantly over the years as a result of technical advances and changes in public attitude. Two technological advances that have had a significant effect are the development of the food processing and packaging industry and the use of kitchen food waste grinders. The percentage of food waste, by weight, has decreased from about 14 percent in the early 1960s to about 9 percent in 1992.

Recently, because the public has become more environmentally aware and concerned, a trend has developed toward the use of more raw, rather than processed, vegetables. While it would appear that such a trend would increase the quantity of food wastes collected no firm data are available on this subject.

Paper and Cardboard. The percentage of paper and cardboard (also known as paperboard and corrugated paper) found in solid wastes has increased greatly over the past half century, rising from about 20 percent in the early 1940s to about 40 percent in 1992. It is expected that use of paper and cardboard will remain stable for the next few years. If the U.S. postal rate for bulk mail were increased to that for first class mail, a significant reduction would occur in the amount of paper collected for disposal.

Yard Wastes. The percentage of yard wastes in MSW has also increased significantly during the past quarter century, due primarily to passage of laws that prohibit burning of yard wastes. By weight, yard waste currently accounts for about 16 to 24 percent of the waste stream. Environmental conditions such as droughts have also affected the quantities of yard wastes collected in certain locations. For example, in Santa Barbara, CA, many areas that had lawns have been converted permanently to arid type landscaping with a concomitant decrease in the portion of yard wastes. Whether drought conditions in the south-western United States will continue to affect the quantity of yard wastes is unknown.

TABLE 3-12
Classification of refuse materials in the early 1900s

Municipal refuse	Public refuse		Street manure and litter
			Sweepings and dust
			Leaves
			Droppings from carts
			Large dead animals
			Snow
			Cleanings from public catch basins
	Trade refuse		Steam ashes
			Dry factory wastes
			Slaughter house waste
			Rubbish from office buildings and factories
			Cleanings from private catch basins
	Market refuse		Garbage from markets
			Rubbish and cleanings from markets
			Old boxes and barrels
	Stable refuse		Manure
			Straw
			Cleanings from stables
			Fly maggots
	House refuse	Garbage	Animal matter, including moisture
			Vegetable matter, including moisture
			Tin cans
			Small dead animals
		Ashes	Coal and cinders
			Clinker and slate
			Dust
			Glass
			Crockery
			Brick and stone
			Metal fragments
		Rubbish	Sweepings from buildings
			Boxes and barrels
			Wood
			Paper
			Rags
			Excelsior
			Straw
			Leather
			Rubber
			Metal ware
			Bedding
			Old furniture
		Night soil	Contents of privies

Source: From Ref. 6, adapted from paper entitled "Disposal of Municipal Refuse and Rubbish Incineration," by H. de B. Parsons, *Transactions ASCE*, Vol. LVII, p. 45, 1906.

Plastics. The percentage of plastics in solid wastes has also increased significantly during the past 50 years. The use of plastic has increased from almost nonmeasurable quantities in the early 1940s to between 7 and 8 percent, by weight, in 1992. It is anticipated the the use of plastics will continue to increase, but at a slower rate than during the past 25 years.

3-7 DISCUSSION TOPICS AND PROBLEMS

3-1. Gather data for your community or a nearby community on the total amount of MSW that is now generated, and compute the percentage distribution using the waste categories given in Table 3-3. How does the percentage distribution for your community compare with the distribution given in Table 3-3? If there are major differences, what explanation can you offer for the differences?

3-2. Obtain data for your community or a nearby community on the percentage distribution of the components found in the residential and commercial portion of the MSW. How do the values obtained compare with the typical values given in Table 3-4? Explain any major differences. If the individual component values are not within the ranges given in Table 3-4, explain why.

3-3. A community is now achieving a 25 percent by weight separation of wastes made up of the following items: mixed paper, 44%; cardboard, 6%; plastics, 10%; yard waste, 16%; glass, 12%; and mixed metal (tin cans and other metals), 12%. If the distribution of waste components given in column 3 of Table 3-4 is representative of the wastes that are now collected, determine the *as generated* percentage distribution of the waste components.

3-4. A community is proposing to achieve a 50 percent rate of separation by weight of wastes made up of the following items: mixed paper, 40%; cardboard, 8%; plastics, 8%; yard waste, 24%; glass, 12%; and tin cans, 8%. Determine the *as collected* percentage distribution for the residual waste components, assuming the typical distribution of waste components given in column 4 of Table 3-7 is representative of the wastes that are now generated.

3-5. Identify the materials that are now recovered for recycling in your community. How does your list of materials compare to the list given in Table 3-10? What other materials could be recycled that are not being recycled?

3-6. Describe the general trends you would expect in the future in the generation of the following types of wastes in your community: food wastes, paper, plastics, rags and leather, and yard wastes. What effect will improved reporting techniques have on your answer?

3-8 REFERENCES

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