

Chapter 3

Sources, Types and Composition of Municipal Solid Waste (MSW)

Management of MSW

- Solid wastes include all solid or semisolid materials that the processor no longer considers of sufficient value to retain.
- Before starting to plan management activities, it is important to know as much about MSW as possible.





Important Questions

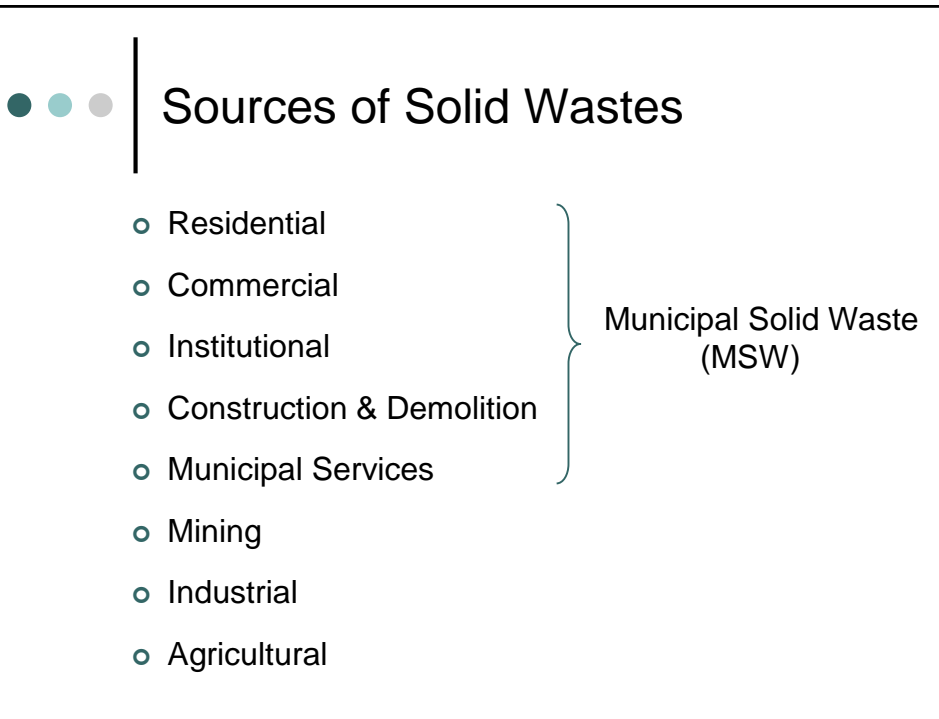
Important questions that must be answered include the following questions;

- What types and quantities of MSW will be received?
- At what rates will these types arrive?
- What types and quantities of materials have already been removed for reuse and recycling?
- What properties does MSW have as it is received?
- How do the properties of MSW vary: hourly, daily, weekly, and seasonally?



Important Questions

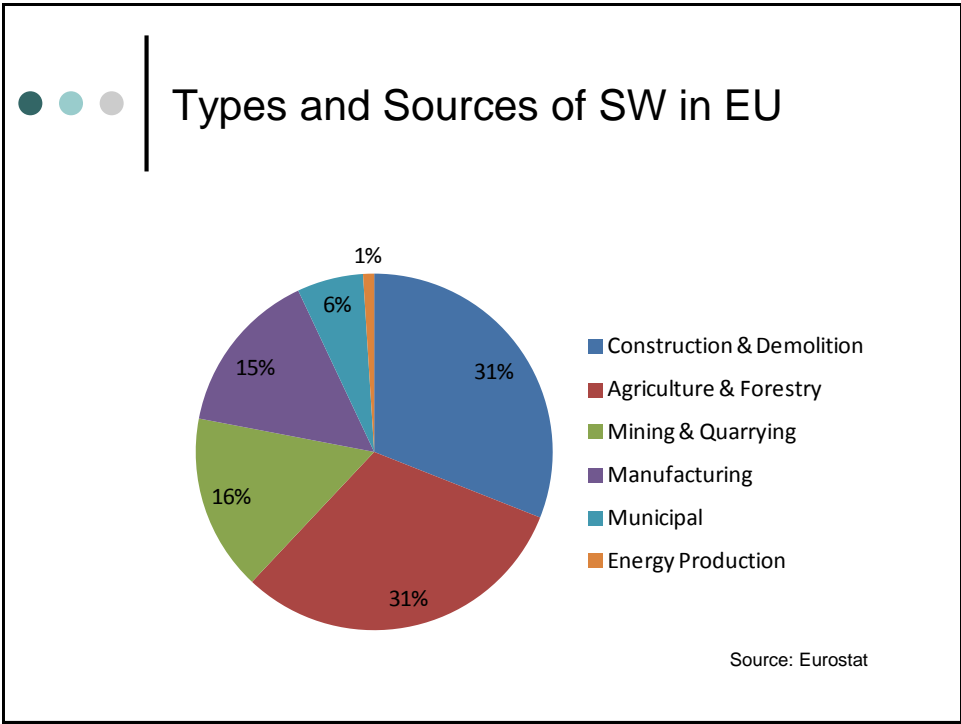
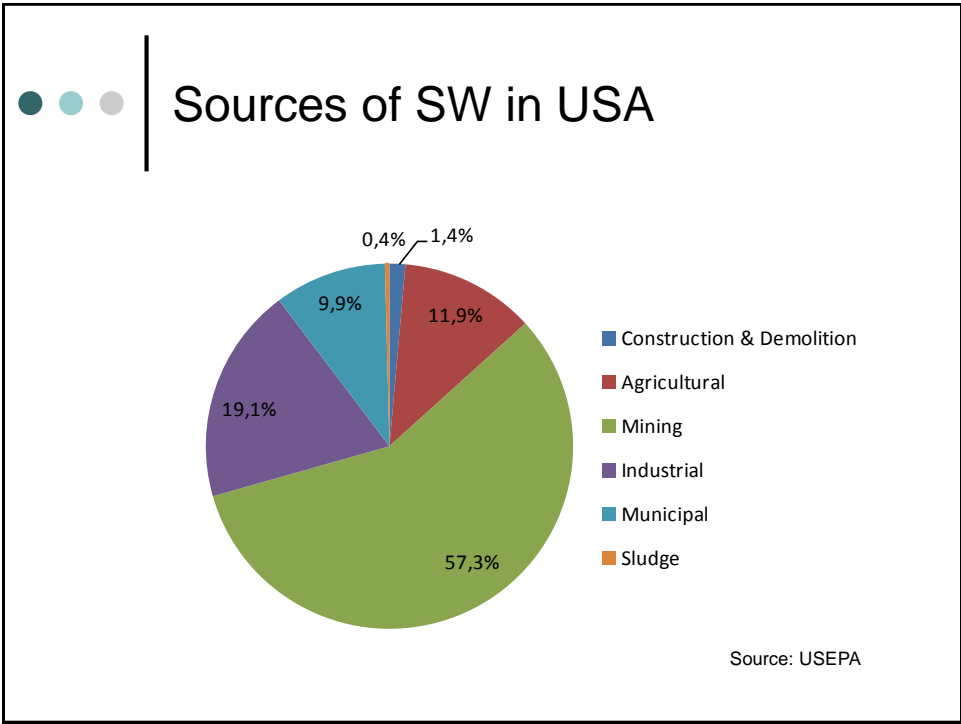
- How do the properties of MSW change during processing?
- What are properties of MSW that are of economic value?
- Which hazardous objects must be removed?
- What contaminants should be removed?
- What test and measurements can be performed to obtain answers to the above questions?
- What range of variations should be expected in the measured quantities and with what level of confidence?



Sources of SW within a community

Textbook, Table 3-1 pp.41

Source	Typical Waste Generators	Types of Solid Wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes).
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Institutional	Schools, hospitals, prisons, government centers.	Same as commercial
Construction & Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Manufacturing Processes	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agricultural	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).





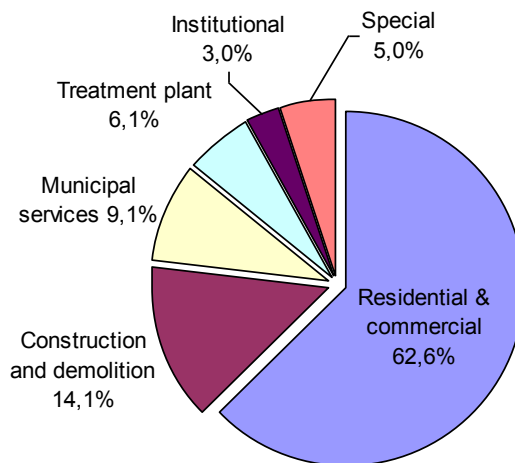
Distribution of components of MSW

Textbook, Table 3-3 pp.48

Waste Category	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 seperately, batteries, oil, and tires)	3-12	5.0
Hazardous	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
TOTAL		100



Distribution of MSW in USA





Sources of MSW in ISTANBUL

- Residential
- Commercial (including open markets)
- Street cleanings
- Tourism activities (Eminönü, Beyoğlu)
- Parks and recreational areas
- Coal ash (still some ...)
- Construction & demolition ??



Composition of Solid Wastes

Distribution for components in MSW vary with;

- Location
- Season
- Economic conditions



Determination of the composition of MSW in the field

- Because of heterogeneous nature of MSW, determination of its composition is not easy.
- Generalized field procedures, based on common sense and random sampling techniques are used.



Determination of the composition of MSW in the field

- A representative residential sample might be a truckload resulting from a typical weekday collection route in a residential area.
- To obtain a sample for analysis, the load is first quartered.



Determination of the composition of MSW in the field

- One part is selected for additional quartering until a sample size of about 100 kg is obtained.
- Sample is then separated manually and each component (glass, plastics, metal, paper etc.) is placed in separated containers.
- Finally, weighed and weights are recorded

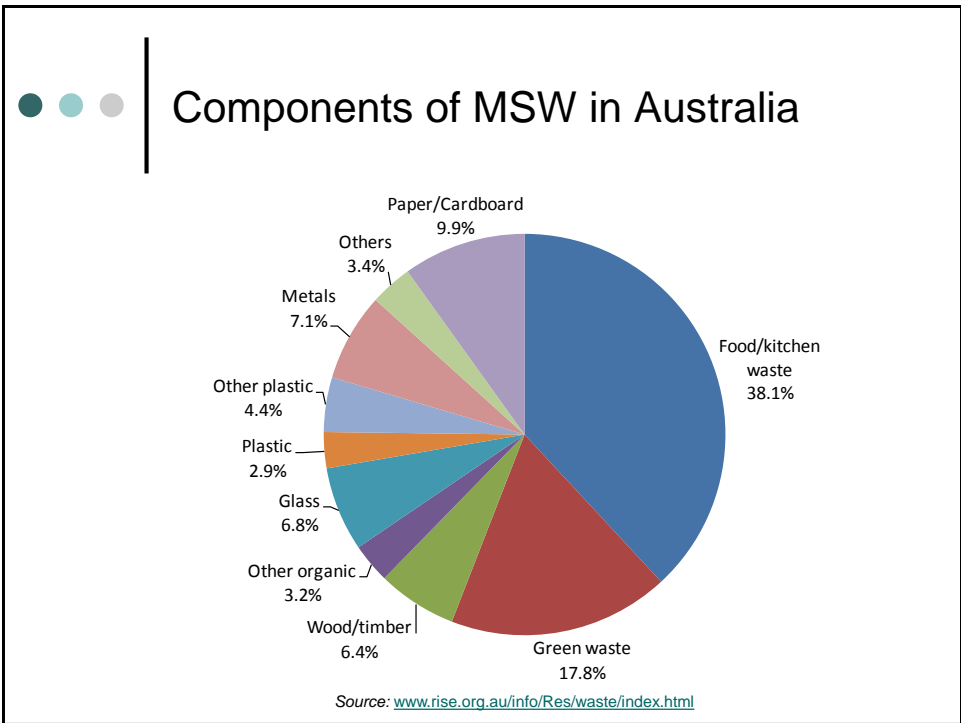
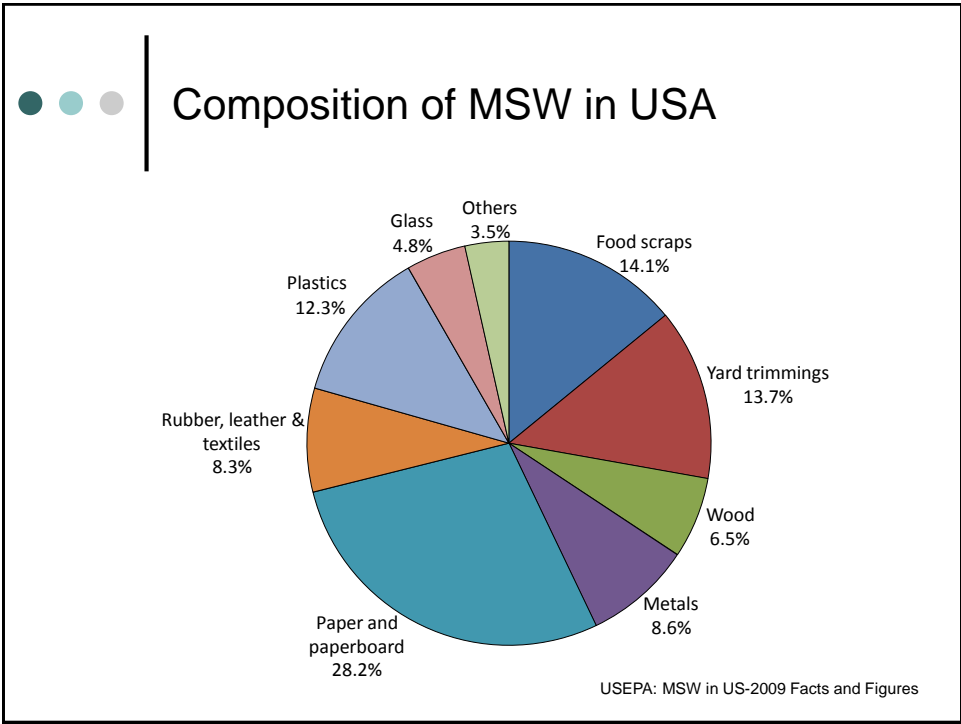


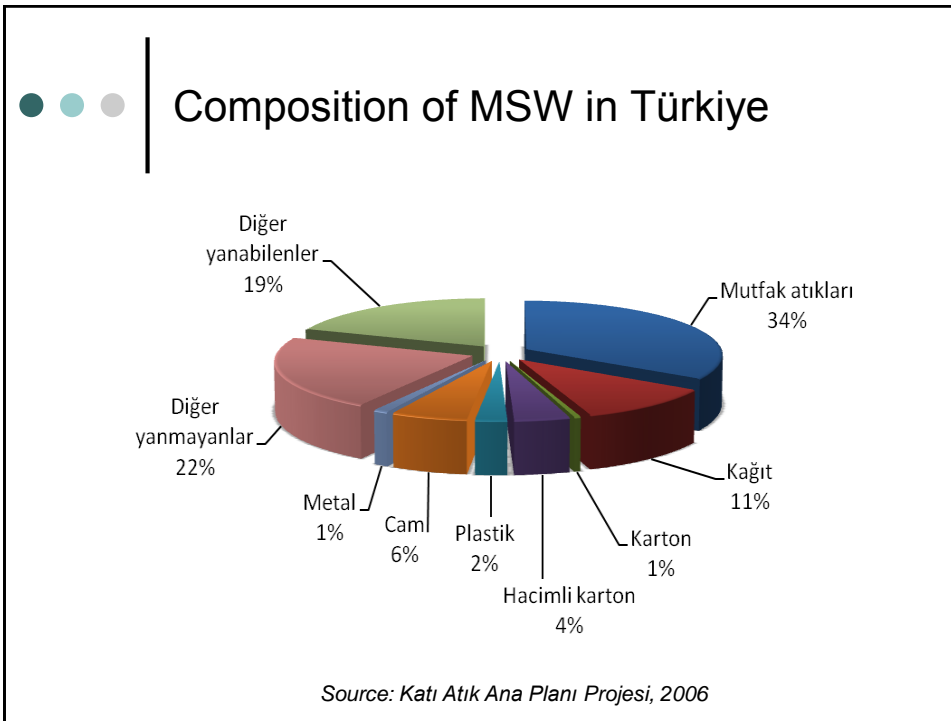
Composition of MSW

Composition of MSW, % by weight (Henry and Heinke, 1996)

Component	US & Canada	France	Helsinki, Finland	Brisbane, Australia	Egypt
Paper	38	28	39	30	13
Plastics	8	5	10	11	2
Food	7	25	25*	18	60
Yard	18	-		24	-
Metal	8	6	4	6	3
Glass	7	8	3	7	2
Rubber, wood, leather	11	6	7	-	2
Miscellaneous	3	22	12	4	18

* Food and yard waste combined





- ### Factors Affecting Generation Rates
- Seasonal Changes
 - Weekly and Daily Variations
 - Source Type
 - Family Size
 - Collection Practice
 - Infrastructure
 - Population Density
 - Economy
 - Statistical Properties



MSW Generation Rates

Country	MSW generation rate (kg/person/year)	Country	MSW generation rate (kg/person/year)
Iceland	1,030	USA	531
Canada	760	Sweden	468
Australia	690	Japan	410
Norway	675	Turkey	330
Denmark	667	Thailand	300
Germany	640	China	290
UK	599	India	180
France	555	Bangladesh	160



MSW Generation Rates

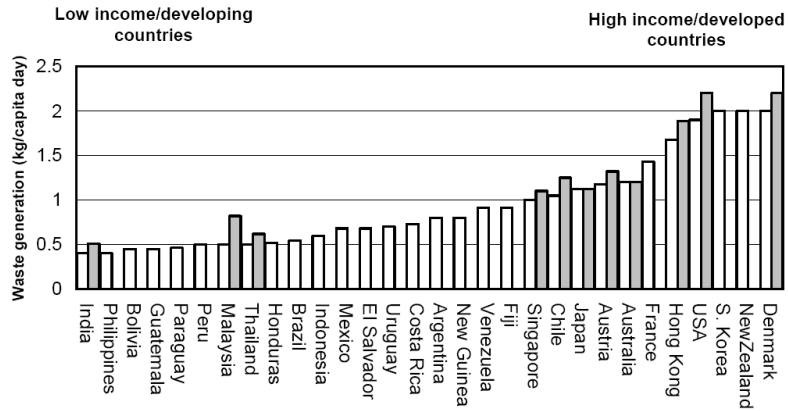
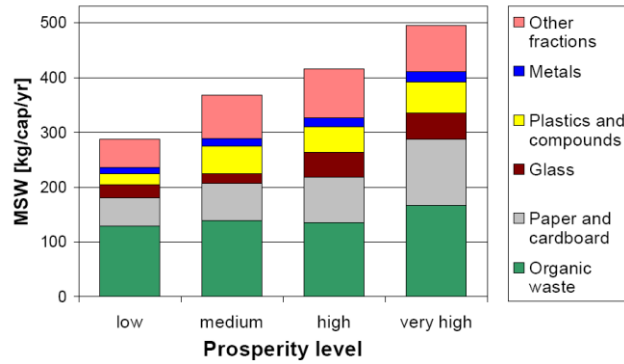


Figure 1.4. Bulk generation of solid waste materials in 1992 (white columns) and 2000 (gray columns) for a range of countries with different levels of industrial development and standard of living.



MSW Generation and Composition in Europe

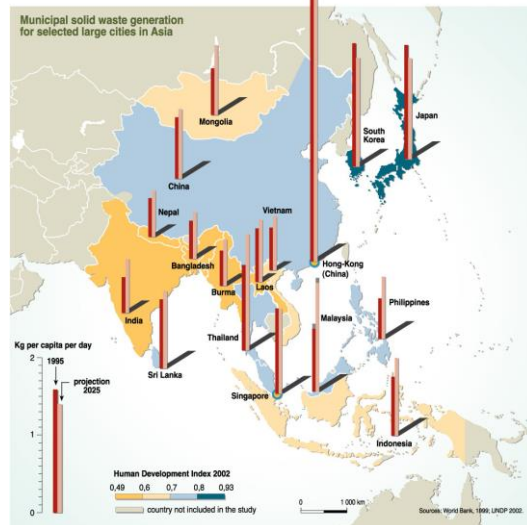
MSW generation rates and composition at different prosperity levels in European cities.




Beigl P, Wassermann G, Schneider F and Salhofer S. Forecasting Municipal Solid Waste Generation in Major European Cities, iEMSs 2004 Int. Conference, 14-17 June, Osnabrück, Germany



MSW Generation Rates in Asia





Materials recovered for recycling from MSW (p.61, Table 3-10)

Recyclable Material	Types of Materials or Uses
Aluminum	Soft drink and beer cans
Paper -Old Newspaper -Corrugated Cardboard -High-Grade Paper -Mixed Paper	-Newsstand and home-delivered newspaper -Bulk packaging -Computer paper -Various mixtures of clean paper
Plastics -Polyethylene Terephthalate (PETE/1) -High-density Polyethylene (HDPE/2) -Polyvinyl Chloride (PVC/3) -Low-density Polyethylene(LDPE/4) -Polypropylene (PP/5) -Polystyrene (PS/6) -Multilayer and other(7) -Mixed Plastics	-Soft drink bottles, salad dressing bottles, etc. -Milk jugs, water containers, detergent etc. -Home landscaping irrigation piping -Thin-film packaging and wraps -Closures and labels for bottles and containers -Packaging for electronic and electrical components -Multi-layered packaging, ketchup and mustard bottles -Various combinations of the above products
Glass	Clear, green, and brown glass bottles and containers
Ferrous Metal	Tin cans, white goods, and other metals



Materials recovered for recycling from MSW (p.61, Table 3-10)

Recyclable Material	Types of Materials or Uses
Non-ferrous 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 & Demolition Waste	Soil, asphalt, concrete, wood, dry wool, metals
Wood	Packing Materials, pallets, scraps, and used wood from construction process
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, plastics and lead
Household Batteries	Potential recovery of zinc, mercury, and silver

Example 3.1 Impact of food waste grinders and waste recycling on distribution of waste components in residential MSW

Assess the impact of the use of food waste grinders & 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 US 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 %

Example 3.1 – Solution (Without Recycling)

Component	MSW as collected	Percent by weight	
		$1 - (0,2 \cdot 0,25) = 0,95$	MSW as collected plus ground up food waste
Organic	(1)	(2)	(2)/100,5
Food wastes	9,0	$9 / 0,95 = 9,47 \approx 9,5$	9,45
Paper	34,0	34,0	33,83
Cardboard	6,0	6,0	5,97
Plastics	7,0	7,0	6,97
Textiles	2,0	2,0	1,99
Rubber	0,5	0,5	0,50
Leather	0,5	0,5	0,50
Yard wastes	18,5	18,5	18,41
Wood	2,0	2,0	1,99
Inorganic			
Glass	8,0	8,0	7,96
Tin cans	6,0	6,0	5,97
Aluminum	0,5	0,5	0,50
Other metal	3,0	3,0	2,99
Dirt, ash, etc	3,0	3,0	2,99
Total	100,0	100,5	100,00

Example 3.1 – Solution (With Recycling)

Component (1)	Percent by weight			Recycled	Non-recycled	Percent by weight		
	MSW as collected incl. recycled items but excl. ground up food waste (2)		Items recycled (not reflected in as collected distribution) (3)	Weight of comp. recycled (11 kg excluding ground up food waste), kg (4)	MSW as collected excl. recycled comp. (89 kg excl. ground up food waste, kg (5)	MSW as collected plus recycled comp. (6)=(4)+(5)		MSW as collected plus recycled and ground up food waste
Organic								
Food wastes	9,0	0,0	0	89*9%=8,01	8,01	8,40	8,37	
Paper	34,0	50,0	11*50%=5,5	30,26	35,76	35,76	35,62	
Cardboard	6,0	10,0	1,1	5,34	6,44	6,44	6,41	
Plastics	7,0	6,0	0,66	6,23	6,89	6,89	6,86	
Textiles	2,0	0,0	0	1,78	1,78	1,78	1,77	
Rubber	0,5	0,0	0	0,445	0,445	0,44	0,44	
Leather	0,5	0,0	0	0,445	0,445	0,44	0,44	
Yard wastes	18,5	8,0	0,88	16,465	17,345	17,34	17,28	
Wood	2,0	0,0	0	1,78	1,78	1,78	1,77	
Inorganic								
Glass	8,0	18,0	1,98	7,12	9,1	9,10	9,06	
Tin cans	6,0	4,0	0,44	5,34	5,78	5,78	5,76	
Aluminum	0,5	1,0	0,11	0,445	0,555	0,55	0,55	
Other metal	3,0	3,0	0,33	2,67	3	3,00	2,99	
Dirt, ash, etc	3,0	0,0	0	2,67	2,67	2,67	2,66	
Total	100,0 %	100,0 %	11 kg	89 kg	100	100,4	100,00	

$$\frac{8,01}{0,95} = 8,40$$

Problem 3.3

A community is now achieving a 25% by weight separation of wastes made up of the following items: mixed paper = 44%; cardboard = 6%; plastics = 10%; yard waste = 16%; mixed metals (tin cans & other metals) = 12%; glass = 12%.

If the distribution of waste components given below is representative of the wastes that are now collected, determine the **as generated** percentage distribution of the waste components.

Component	MSW as collected, % by weight
Organic	
Food wastes	9,0
Paper	34,0
Cardboard	6,0
Plastics	7,0
Textiles	2,0
Rubber	0,5
Leather	0,5
Yard wastes	18,5
Wood	2,0
Inorganic	
Glass	8,0
Tin cans	6,0
Aluminum	0,5
Other metal	3,0
Dirt, ash, etc	3,0
Total	100,0

Solution 3.3

Component	MSW as collected (excl. separated comp.), %	Comp. separated for recycling, %	Weight of comp. separated (25 kg)	Weight of MSW excl. separated comp. (75 kg)	As generated MSW incl. separated comp., %
Organic					
Food wastes	9,0			6,75	6,75
Paper	34,0	44,0	11,0	25,50	36,50
Cardboard	6,0	6,0	1,5	4,50	6,00
Plastics	7,0	10,0	2,5	5,25	7,75
Textiles	2,0			1,50	1,50
Rubber	0,5			0,38	0,38
Leather	0,5			0,38	0,38
Yard wastes	18,5	16,0	4,0	13,88	17,88
Wood	2,0			1,50	1,50
Inorganic					
Glass	8,0	12,0	3,0	6,00	9,00
Tin cans					
Aluminum	9,5	12,0	3,0	7,13	10,13
Other metal					
Dirt, ash, etc	3,0			2,25	2,25
Total	100,0%	100,0%	25,0 kg	75,00 kg	100,00%

Problem 3.4

A community is proposing a 50% rate of separation by weight wastes made up of the following items: mixed paper = 40%; cardboard = 8%; plastics = 8%; yard waste = 24%; tin cans = 8%; glass = 12%.

Determine the ***as collected*** percentage distribution for the residual waste components assuming the distribution of waste components given below is representative of the wastes that are now generated.

Component	MSW as generated, % by weight
Organic	
Food wastes	8,0
Paper	35,8
Cardboard	6,4
Plastics	6,9
Textiles	1,8
Rubber	0,4
Leather	0,4
Yard wastes	17,3
Wood	1,8
Inorganic	
Glass	9,1
Tin cans	5,8
Aluminum	0,6
Other metal	3,0
Dirt, ash, etc	2,7
Total	100,0



Solution 3.4

Component	MSW as generated incl. recycled comp., %	Weight of MSW comp. (100 kg)	Comp. separated, %	Weight of comp. separated (50kg)	Weight of MSW excl. separated comp. (50 kg)	As collected MSW comp., %
Organic						
Food wastes	8,0	8,0			8,0	16
Paper	35,8	35,8	40,0	20,0	15,8	31,6
Cardboard	6,4	6,4	8,0	4,0	2,4	4,8
Plastics	6,9	6,9	8,0	4,0	2,9	7,8
Textiles	1,8	1,8			1,8	3,6
Rubber	0,4	0,4			0,4	0,8
Leather	0,4	0,4			0,4	0,8
Yard wastes	17,3	17,3	24,0	12,0	5,3	10,6
Wood	1,8	1,8			1,8	3,6
Inorganic						
Glass	9,1	9,1	12,0	6,0	3,1	6,2
Tin cans	5,8	5,8	8,0	4,0	1,8	3,6
Aluminum	0,6	0,6			0,6	1,2
Other metal	3,0	3,0			3,0	6,0
Dirt, ash, etc	2,7	2,7			2,7	5,4
Total	100,0%	100,0 kg	100,0%	50,0 kg	50,0 kg	100,0%