1.

Component	% by mass	%Moisture content	Energy content(kJ/kg)	Dry mass(kg)	Total Energy(kJ)
Food waste	15	70	3650	4.5	54750
Paper	45	6	18750	42.3	843750
Cardboard	10	5	14300	9.5	143000
Plastic	10	15	30600	8.5	306000
Garden trimmings	10	50	6600	5	66000
Wood	6	20	18600	4.8	111600
Tin cans	2	4	700	1.92	1400
	98			76.52	1526500

Unit energy content based on 100kg sample $= \frac{1526500}{100} = 15265\ kJ/kg$

a) Dry basis: kJ/kg $= 15265 * \frac{100}{100 - \%\ mc}$

Moisture content $= \frac{a-b}{a}$ x $100 = \frac{98-76.52}{98}$ x 100 = 21.92%

Energy content (Dry basis) kJ/kg $= 15265 * \left\{\frac{100}{100-21.92}\right\}$ = 19550.46 kJ/kg

b) Ash free dry basis:-

Energy content kJ/kg $= 15265 * \left\{\frac{100}{100 - \%\ \text{Ash} - \%mc}\right\}$

$\left\{\frac{100}{100-5-21.92}\right\}$

= 20888.068 kJ/kg

2.

Component	%By mass	%Moisture content	Typical density(kg/m^3)	Dry mass(kg)	Volume(m^3)
Food waste	26	70	290	7.8	0.897
Paper	28	6	70	26.32	4
Cardboard	24	6	85	22.56	2.824
Plastic	11	2	65	10.78	1.692
Textile	11	7	16	10.23	6.875
				77.69	16.288

Moisture content $= \frac{a-b}{a} X\ 100$

$= \frac{100-77.69}{100} X\ 100$

Moisture content =22.31 %

Density = Weight per unit volume $= \frac{1000}{16.288}$

Density = 61.394 kg/m^3

3. **Properties of Solid waste:**

Importance: Information on properties of solid waste is important in evaluating alternative equipment needs, system and management programmes and plans especially with reference to the implementation of disposal and resource and energy recovery operations.

Physical Properties:-

a) Individual components
b) Particle size
c) Moisture content
d) Density

Chemical composition or properties:

a) Proximate analysis
   - → Moisture (loss at 105^0C for 1 hour)
   - → Volatile (Additional loss matter on ignition at 950^0C)
   - → Ash (Residue after burning)
   - → Fixed carbon (Remaining un burnt material)

b) Fusing point of Ash
c) Ultimate analysis - % C,H,O,N,S and Ash
d) Heating value (energy value)

Physical properties:

Information and date of physical properties include.

1) Identification of Individual components that make up MSW.

2) **Particle Size:** The size distribution of the component materials in solid waste include consideration in the recovery of materials specially with mechanical means such as magnetic separators.

3) Moisture content:

The moisture content of solid waste usually expressed as the mass of moisture per unit mass of weight of wet or dry material. In the wet mass of method of measurement the moisture in a sample is expressed as % of wet mass of the material. In dry mass method it is expressed as % of dry mass of the material. In equation form the wet mass moisture content is expressed as follows.

Moisture content (%) = $\frac{a-b}{a}$ x 100

where

'a' = initial mass of mass of sample as delivered.

'b' = mass of sample after drying.

4. Density: The density of solid waste vary markedly with geographic location, season of the year, length of time in storage, great care should be used in selecting the typical values. Density of a material is its mass per unit volume. Density differs with buoyancy, purity and packaging. Density of material varies with temperature and pressure.

Chemical composition or properties:

Proximate analysis:

Proximate analysis for the combustible components for MSW includes the following tests.

a) Moisture – when heated to 105^0c for 1 hour.
b) Volatile combustible matter – additional loss of weight at 950^0C in a covered crucible.
c) Fixed carbon - Combustible residue left after volatile matter is removed.
d) Ash – Weight of residue after combustion in an open crucible.
e) It is important to note that the test used to determine volatile combustible matter in a proximate analysis is different from the volatile solids test used in biological determination.

Energy Content

In general the data on the energy content of the organic components of MSW are based on the results of bomb calorimeter tests. The energy content values are on as discarded basis.

The energy values may be converted to a dry basis by the following equation

kJ/kg (dry basis) = unit energy content kJ/kg (as discarded) * $\frac{100}{100-\%\, moisture}$

The corresponding equation on as Ash free dry basis is

$$\text{KJ/kg (dry basis)} = \text{kJ/kg (as discarded)} = \text{unit energy content} \times \frac{100}{100 - \%Ash - \%\, moisture}$$

Ultimate Analysis:

To identify % of C,H,O,N,S and Ash.

4. Sources of Solid wastes:

Sources of solid wastes in a community are in general related to land use and zoning. One method of classification is as follows:

1. Residential
2. Commercial
3. Institutional
4. Construction and demolition
5. Municipal services.
6. Treatment plant site
7. Industrial and
8. Agricultural

The different types of solid wastes that are generated are as follows.

Garbage: The organic fraction of residential and commercial solid which consists of materials such as food waste that decompose rapidly especially in warm weather is called as Garbage. This is also known as putrescible waste.

Rubbish wastes:- Combustible and non-combustible solid waste, excluding food waste or other putrescible materials. Typically combustible rubbish consists of materials such as paper, card board, plastic, textiles, rubber, leather wood, Furniture and garden trimmings.

Non combustible rubbish consists of items such as glass, crockery, tin cans, Aluminum case, Ferrous and non Ferrous metals, dirt and construction waste.

Ashes and Residue: Materials remaining from burning of food, coal, coke and other combustible wastes. Residues from power plants normally are not included in this category. **Demolishing and construction waste**: Waste from residential buildings and other structures are classified as demolition waste. Waste from construction, remodeling and repairing of residential, commercial and industrial building and similar structures are classified as construction waste. These wastes may include dirt, stones, concrete, bricks, plaster and plumbing, heating and electrical materials.

Special wastes or Wastes from municipal services:-
Wastes such as rubbish, street sweepings, landscape and tree trimmings, catch basin debris, general wastes from parks and recreational areas. It also includes dead animals abandoned vehicles.

Treatment plant waste: The solid and semisolid waste from water, water and industrial waste treatment facilities are included in this classification treatment plant wastes mainly consists of residual sludge.

Industrial solid waste: These wastes arise from industrial activities and include rubbish, ashes, demolition waste.

Sources of municipal solid waste:

General Sources of MSW:

Sl No	Source	Typical facilities, Activities or locations where waste are generated	Types of Solid waste
1	Residential	Single family, Multi family dwellings, low, medium and high raise apartments etc	Food waste, rubbish, ashes, special wastes
2	Commercial	Stores, restaurants, Markets, office buildings, hotels, print shops, Auto repair shops, Medical facilities, Institutions etc.	Food waste, rubbish, ashes, demolition and construction waste special waste,etc
3	Open areas	Street, parks, playground, vacant plots, beaches, highways, recreational areas etc.	Special wastes, rubbish.
4	Treatment plant site	Water, waste water, Industrial treatment process etc	Treatment plant waste composed of residual sludge.

5. Types of collection systems:

Based on their mode of operation collection system are classified into 2 categories.

a) Hauled container systems
b) Stationary container systems.

Hauled container system (HCS):

Containers used for the storage of wastes are hauled to the disposal site, emptied and returned to either their original location or some other location. Hauled containers systems are ideally suited for the removal of wastes from sources, where the rate of generation is high. In this system containers of different sizes and shapes can be used and the use of such large containers reduce handling time. Hauled container systems have the advantage of requiring only truck and driver to accomplish the collection cycle. These are three main types hauled container system:

1. **Hoist truck systems**: It is used for the collection of wastes by a collector who has a small operation and collects from only a few pick up points at which considerable amounts of wastes are generated.
2. **Tilt Frame container system**
3. **Trash – trailer systems**

Stationary container systems (SCS)

Stationary container system may be used for the collection of all types of wastes. The systems vary according to the type and quantity of wastes to be handled, as well as the number of generation points. These are two main types.

This system is not suited for the collection of heavy industrial wastes and bulk rubbish like construction and demolition waste.

System with manually loaded collection vehicles:- In this system the collector manually empties the contents of a container into a collection vehicle. The major application of this system is in the collection of residential wastes and litter. Manual methods are used for residential collection because many individual pick up points are inaccessible to mechanized self loading collection vehicle.

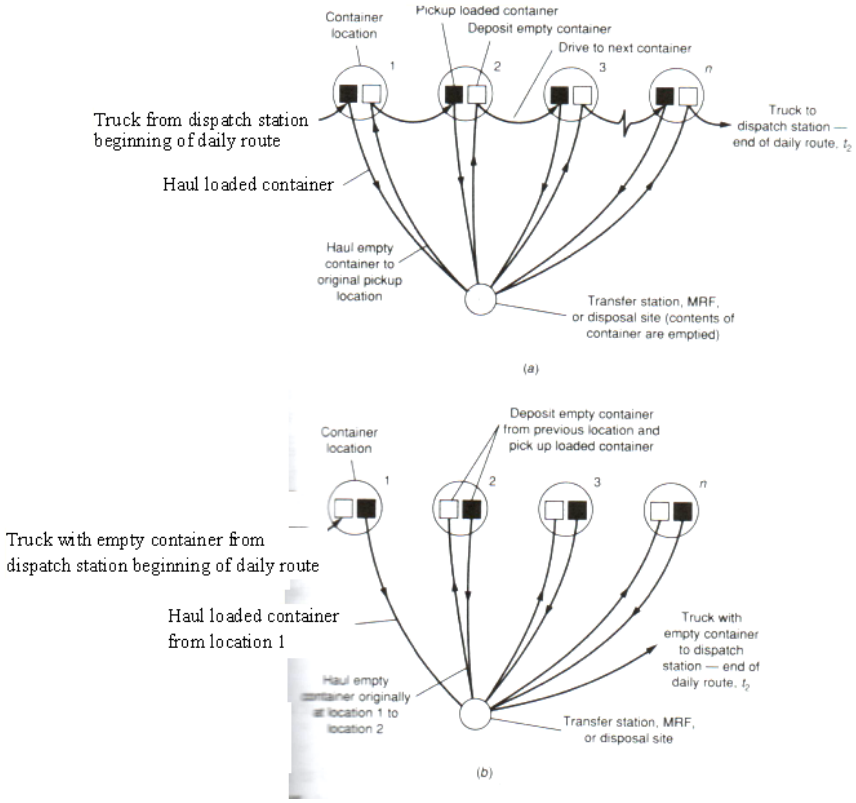

Figure Schematic of operational sequence for hauled container system a) conventional mode and b) exchange container mode

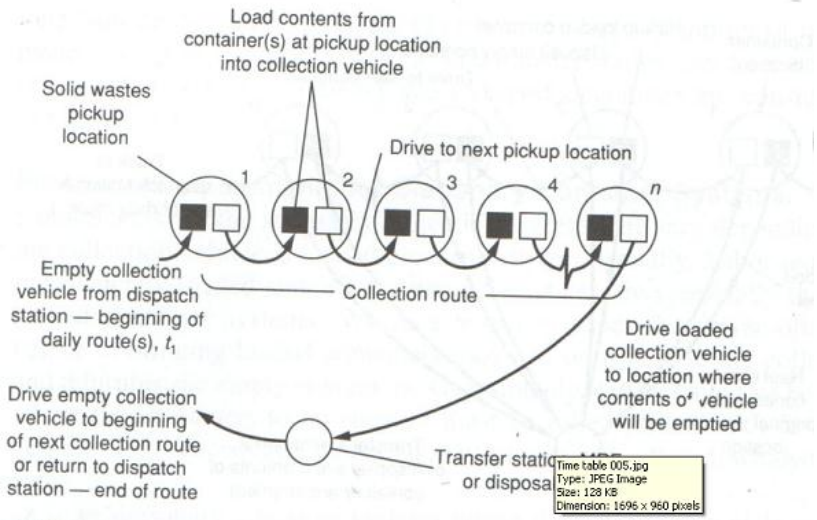

FIGURE
Schematic of operational sequence for stationary container system.

6. **Route optimization:**

Once equipment and labour requirements are determined, collection routes must be laid out so that both the collectors and equipments are used effectively. In general the layout of collection route involves a series of trials. There is no universal set of routes that can be applied for all the solutions. Some guidelines that should be taken into consideration when laying out routes are as follows:-

1. Existing policies and regulations related to such items such as the point of collection and frequency of collection must be identified.
2. Existing system characteristics such as crew size and vehicle type must be co-ordinated.
3. Where ever possible route should be laid down so that they begin and end near arterial roads using topographical and physical barriers as route boundaries.
4. In hilly areas route should start at the top of the grade and proceed downhill as the vehicle is loaded.
5. Waste generated at traffic congested location should be collected as early as possible.

Layout of collection routes (general steps involved):

1. Preparation of location maps showing pertinent data and information concerning waste generation sources.
2. Data analysis and as required preparation of information summary table.
3. Preliminary layout of routes.
4. Evaluation of preliminary routes and development of balanced routes by successive trails.

6.Transfer station:

A facility where solid waste materials including yard waste, demolition materials and household refuse are transferred from small vehicles to large trucks for efficient transport to landfills, recycling centers and other disposal sites.

OR

A transfer station is a location that facilitates the intermediary transport waste which serves to temporarily store refuse collected through out the city before a larger truck is ready to pick it up and transport it for long haul to the nearest land fill.

Depending on the method used to load the transport vehicles, transfer stations may be classified into three general types.

1. Direct load.
2. Storage load.
3. Combined direct load and discharge load.

Direct load: In a direct load transfer station, waste from the collection vehicles usually are emptied directly into the vehicles, to be used to transport them to a place of final disposal. To accomplish this these stations usually are constructed in a two level arrangement. The unloading

platform from which wastes from collection vehicles are discharged into the transport trailors. Direct load transfer stations employ stationary compactors also.

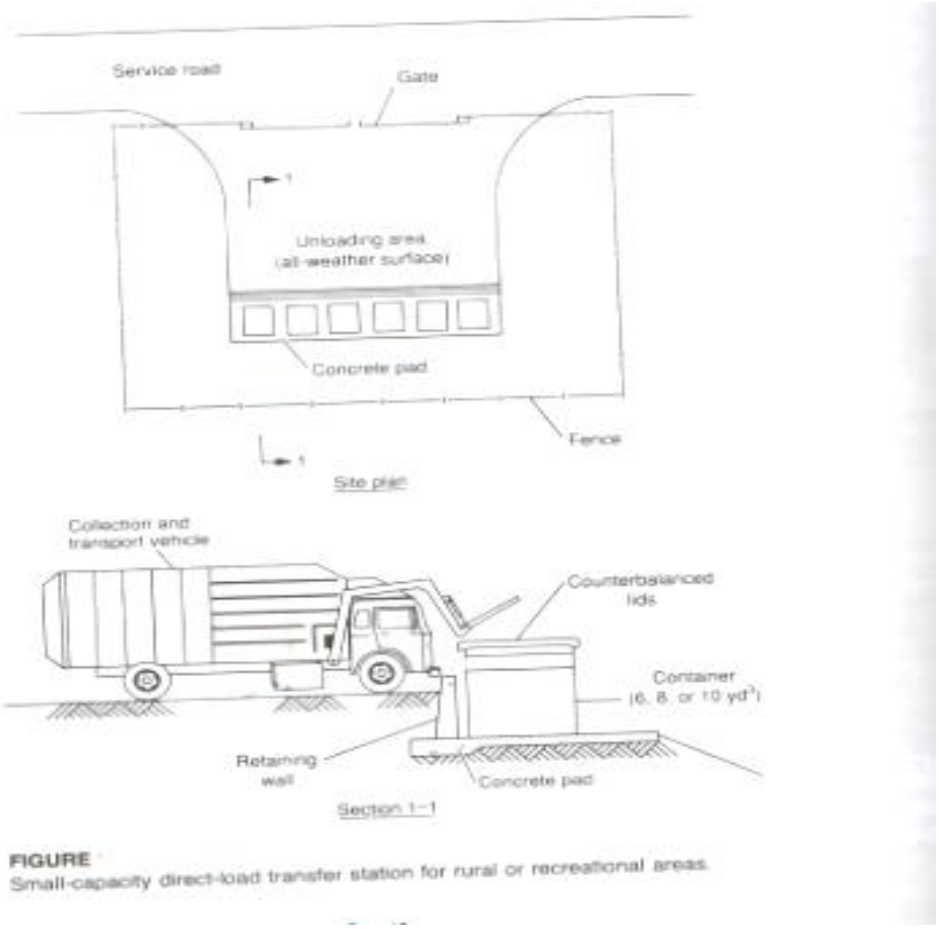

FIGURE
Small-capacity direct-load transfer station for rural or recreational areas.

Storage load: In the storage load transfer station, wastes are emptied either into a storage pit or into a platform from which they are loaded in to transport vehicles by various types of auxiliary equipment. In a storage discharge station various processing techniques like shredding, separation and compaction are employed by using various auxiliary equipments.

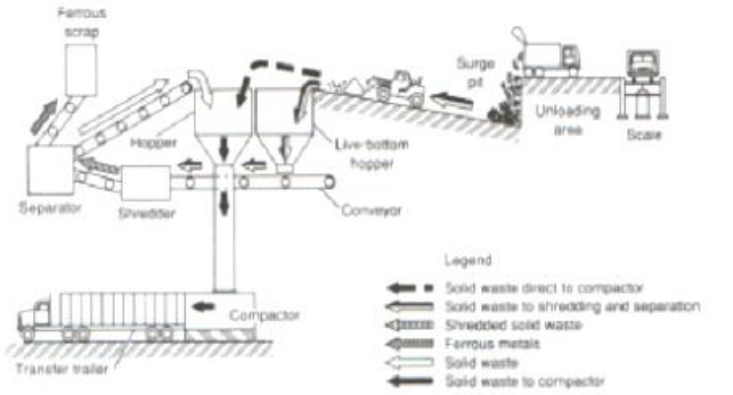

FIGURE
Storage-load transfer station with processing and compaction facilities. (Courtesy of Municipality of Metropolitan Toronto, Department of Public Works.)

Combined direct load and discharge load:

In some transfer stations, both the methods are used usually these are multipurpose facilities, designed to serve a broader range of users than a single purpose facility. This multipurpose transfer station can also house a material recovery unit.