B.Sc. Course(First Semester)

University of Babylon-College of Engineering

Environmental Engineering Department

Chapter Five (Solid Waste Management)

5.1 Waste Handling And Separation, Storage And Processing At Source

In general, handling refers to the activities associated with managing solid wastes until they are placed in the containers used for their storage before collection. Handling may also be required to move the loaded containers to the collection point and to return the empty containers to the point where they are stored between collections(Fig.5.1)and (Fig.5.2)

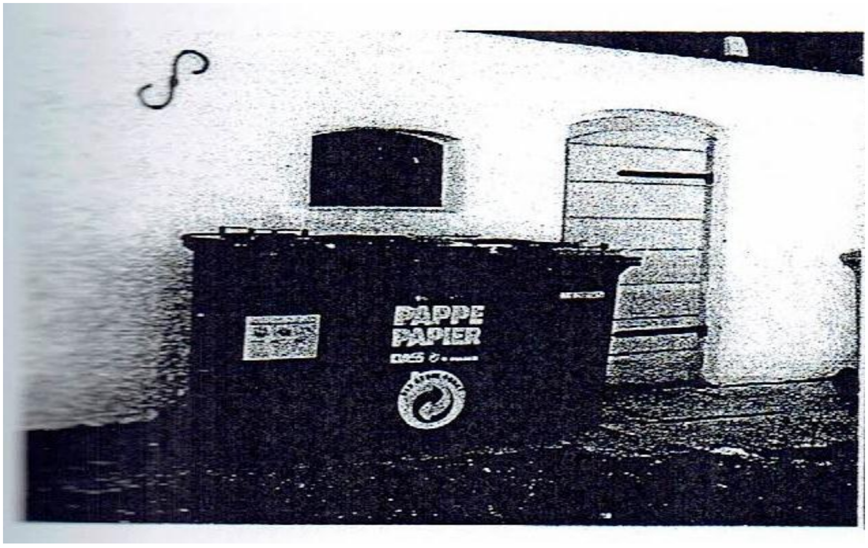

Fig.5.1: Typical storage containers for curb collection service.

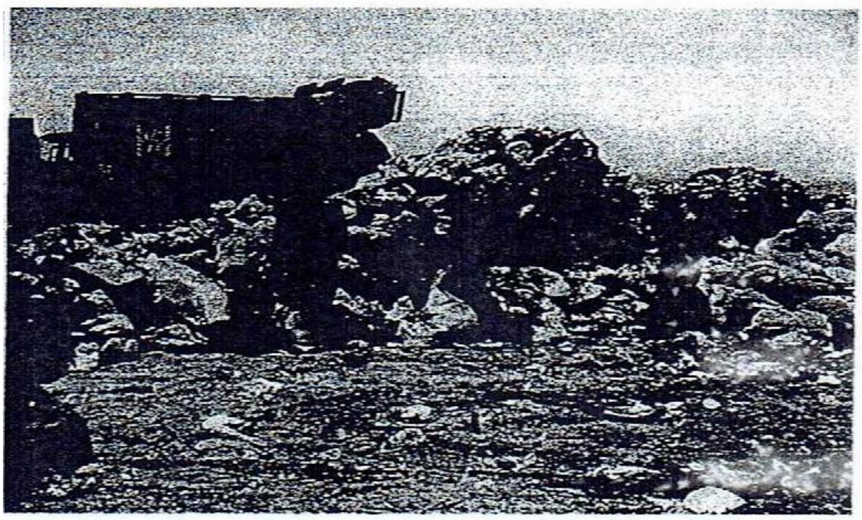

Fig.5.2: Solid waste scavengers

In some residence, waste compactors are being used to reduce the volume of waste to be collected. Compacted wastes are usually placed in waste containers or in sealed plastic bags.

There are number of different collection system, with and without recycling and many others. Two residential waste separation system are compared in example 5.1.

Example 5.1: Comparison of residential waste separation programs.

The effectiveness of residential waste separation programs depends on the type of system used for the collection of separated wastes. A number of communities use a collection system in which three containers are used for recycled materials in addition to one or more containers for non-recyclable materials. In the three container system (system1), newspaper is placed in one container. Aluminum, cans, glass, and plastics are placed in the second container. The remaining wastes are placed in the third container. The separated materials, placed in special containers, are collected at the curb.

In another system(system2), four containers areused. All paper and cardboard materials are placed in one container. All plastic, glass, tin cans, aluminum, and any other metals are placed in a second container. Garden wastes are placed in the third container, and all remaining waste materials are placed in the fourth container. Compare these two systems, assume newspaper represents 25 percent of the total amount of paper.

Solution:

Determine realistically how much of the waste stream can be separated for recycling using the two systems described above. Assume 80 percent of the available material is separated and the participation rate is 100 percent. An estimate of the amount of solid waste that can be separated using the above system is presented in the following table.

	Percent by weight			
	Recycling system 1		Recycling system 2	
Component	As generated[a,b]	Separated for recycle[c]	As generated[a,b]	Separated for recycle[d]
Organic				
Food wastes	9.0 (3)[e]		9.0 (4)[e]	
Paper	**34.0** (1)	6.8[f]	**34.0** (1)	27.2
Cardboard	6.0 (3)		**6.0** (1)	4.8
Plastics	**7.0** (2)	5.6	**7.0** (2)	5.6
Textiles	2.0 (3)		2.0 (4)	
Rubber	0.5 (3)		0.5 (4)	
Leather	0.5 (3)		0.5 (4)	
Yard wastes	18.5 (3)		**18.5** (3)	14.8
Wood	2.0 (3)		2.0 (4)	
Misc. organics	—	—	—	
Inorganic				
Glass	**8.0** (2)	6.4	**8.0** (2)	6.4
Tin cans	6.0 (3)		**6.0** (2)	4.8
Aluminum	**0.5** (2)	0.4	**0.5** (2)	0.4
Other metal	3.0 (3)		**3.0** (2)	2.4
Dirt, ash, etc.	3.0 (3)		3.0 (4)	
Total	100.0	19.2	100.0	66.4

[a] From Table 1.
[b] Waste components that are to be recycled are shown in bold.
[c] Based on 80 percent recovery with 100 percent participation. If only 50 percent of the homes participate, the recycling rate drops to about 9.6 percent.
[d] Based on 80 percent recovery with 100 percent participation. If only 50 percent of the homes participate, the recycling rate drops to about 33.2 percent.
[e] Container number
` $6.8 = 34.0 \times 0.25 \times 0.8$

Comment: as shown in above computation table, the amount of material separated for recycling with system1 is 19.2 percent versus 66.4 percent for system2. If the participation rate were to drop to 50 percent, the corresponding amounts are 9.6 versus 33.2percent. using system1, it will be difficult to achieve the 25 percent recycling goal without a high degree of homeowner participation. Additional separation, possibly at a MRF, will be required to reach the 50 percent goal by the year 2000. Using system, both the 25 and 50 percent diversion goals are achievable with a reasonable amount of homeowner participation.

At Low-and Medium-Rise Apartments

Handling methods in most low- and medium-rise apartment buildings resemble those used for low-rise dwellings, but methods may vary somewhat depending on the waste storage location and collection method. Typical solid waste storage locations include basement storage, outdoor storage, and, occasionally, compactor storage.

At High-Rise Apartments

In high-rise apartment buildings the most common methods of handling solid wastes involve one or more of the following:

1. Wastes are picked up by building maintenance personnel or porters from the various floors and taken to the basement or service area;
2. Wastes are taken to the basement or service area by tenants; or
3. Wastes, usually bagged, are placed by the tenants in specially designed vertical chutes (usually circular) with openings located on each floor (see Fig.5.3).

Wastes discharged in chutes are collected in large containers, compacted into large containers, or baled directly-Recyclable materials may be put outside in the hall or entry way for pickup, or they may be taken by the tenants to the service area located on each floor for pickup. The entrance to the waste chute is usually located in the service area. Bulky items are usually taken to the service area by the tenants or the building maintenance crew.

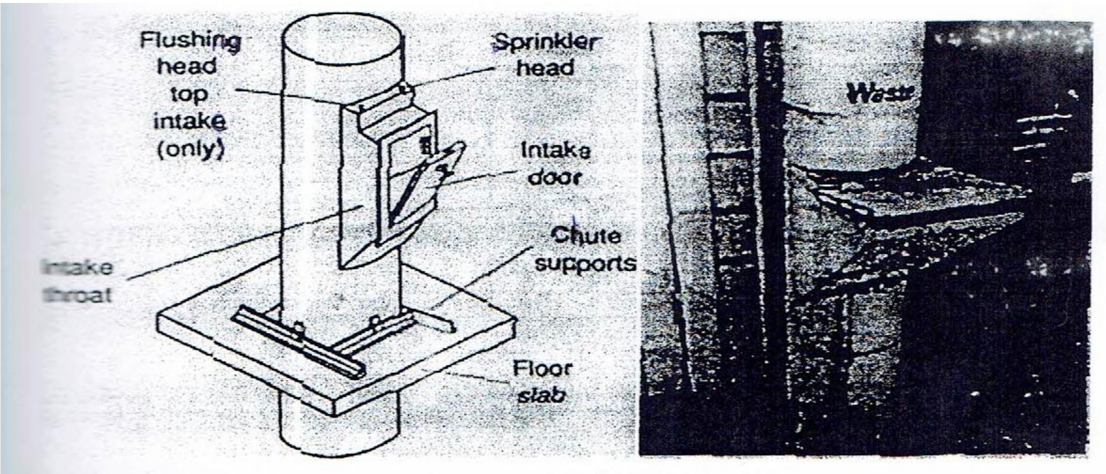

Fig.5.3:Typical chute openings for the discharge of waste materials in high-rise apartment buildings: (a) isometric view of waste chute opening on individual floor and (b) outdoor type used in some older high-rise apartment building.

Chutes for use in apartment buildings are available in, diameters from 12 to 36 in. The most common size is 24 in diameter. All the available chutes can be furnished with suitable intake doors.

In some of the more recent apartment building developments underground pneumatic transport system have been used in conjunction with the individual apartment chutes. The underground pneumatics system are used to transport the wastes from the chute discharge points in each building to a central location for storage in large containers or onsite processing. Both air pressure and Vacuum transport systems have been used in this application.

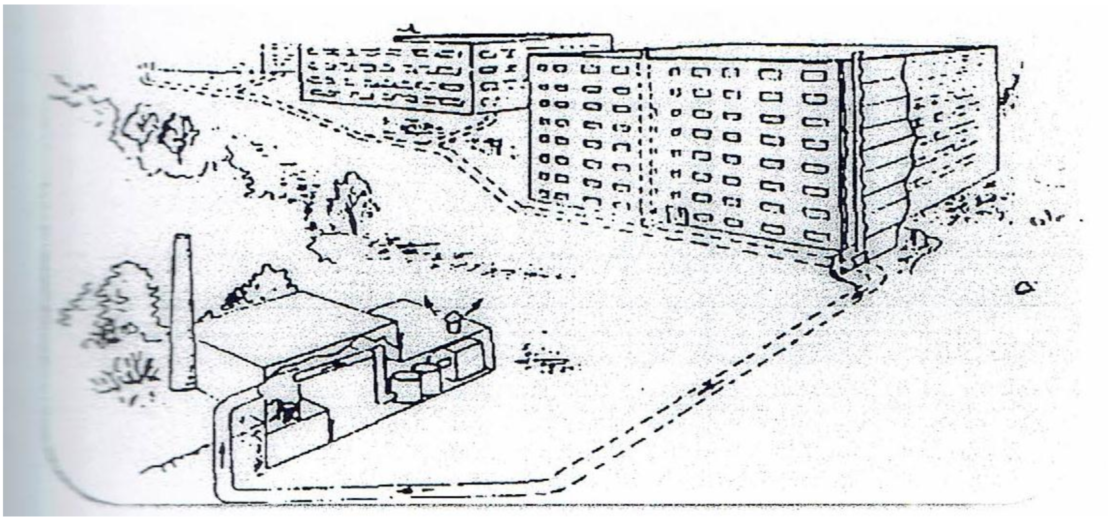

Fig.5.4: Pneumatic transport systems for solid wastes.

5.2 Storage Of Solid Wastes At The Source

Factors that must be considered in the onsite storage of solid wastes include:

1. The effects of storage on the waste components
2. The type of container to be used
3. The container location, and
4. Public health and aesthetics.

1. Effects of storage on waste components

An important consideration in the onsite storage of wastes are the effects of storage itself on the characteristics of the wastes being stored. These effects of storing wastes include:

a. Biological decomposition,
b. The absorption of fluids and
c. The contamination of waste components.

a.Biological decomposition or Microbiological Decomposition

Food and other wastes placed in on site storage containers will almost immediately start to undergo microbiological decomposition (often called putrefaction) as a result of the growth of bacteria and fungi. If wastes are allowed to remain in storage containers for extended periods of time, flies can start to breed and odorous compounds can develop.

b*. *Absorption of fluids

Because the components that comprise solid wastes have differing initial moisture contents re-equilibration takes place as wastes are stored onsite in containers. Where mixed wastes are stored together, paper will absorb moisture from food waste sand fresh garden trimmings. The degree of adsorption that takes place depends on the length of time the waste are stored until collection.

c. Contamination of waste components.

Perhaps the most serious effect of onsite storage of wastes is the contamination that occurs. The major waste components may be contaminated by small amounts of wastes such as motor oils, household cleaners, and paints. The effect of this contamination is to reduce the value of the individual components for recycling.

2. Types of Containers

To a large extent, the types and capacities of the containers used depend on:

a. The characteristics and types of solid wastes to be collected,
b. The type of collection system in use,
c. The collection frequency, and
d. The space available for the placement of containers.

Because solid waste is collected manually from most residential low-rise detached dwellings, the container should be light enough to be handled easily by one collector when full. Injuries to collectors have resulted from handling containers that were loaded too heavy Table5.1 gives data on the types of containers and advantages and disadvantages of each.

Table5.1:Data on the types of containers and advantages and disadvantages of each.

Container type	Limitations
Galvanized	Containers are damaged over time and degraded in appearance and capacity; containers add extra weight that must be lifted during collection operations, tend to be noisy when being emptied and, in time can be damaged so that a proper lid seal cannot be achieved.
Plastic	Containers are damaged over time and degraded in appearance, some containers constructed of plastic materials tend to crack under exposure to the ultraviolet rays of the sun and to freezing temperatures, but the more expensive plastic containers apparently do not present these problems.
Disposal paper bags	Bag storage is more costly: if bags are set out on streets or curbside, dogs or other animals tear them and spread their contents: paper bags themselves add to the waste load. Paper and cardboard containers tend to disintegrate because of the leakage of liquids.
Disposal plastic bags	Bag storage is more costly; bags tear easily, causing litter and unsightly conditions: bags become brittle in very cold weather, causing breakage; plastic lightness and durability causes later disposal problems. In extremely warm areas where disposable plastic bags are used for lawn trimmings, plastic containers frequently stretch or break at the seams when the collector lifts the loaded bag. Such breakage is potentially hazardous and may lead to injuries to the collector because of the presence of glass and sharp or otherwise dangerous items in the wastes.

3. Container Storage Locations

Container storage locations depends on the type of the dwelling or commercial and industrial facilities, the available space, and access to collection services.

4. Public Health and Aesthetics

Although residential solid wastes account for a relatively small proportion of the total wastes generated in the United States (10 to 15 percent), they are perhaps the most important because they are generated in areas with limited storage space. As a result, they can have significant public health and aesthetic impacts.

Public health concerns are related primarily to the infestation of areas used for the storage of solid wastes with vermin and insects that often serve as potential disease vectors. By far the most effective control measure for both rats and flies is proper sanitation. Typically, ***proper sanitation involves:***

- ❖ The use of containers with tight lids,
- ❖ The periodic washing of the containers as well as of the storage areas, and

❖ The periodic removal of biodegradable materials (usually within less than 8 days), which is especially important in areas with warm climates.

Aesthetic considerations are related to the production of odors and the unsightly conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions.

❖ Most odors can be controlled through the use of containers with tight lids

❖ Maintenance of a reasonable collection frequency.

❖ If odors persist, the contents of the container can be sprayed with a masking deodorant as a temporary expedient.

❖ To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

5.3 Processing Of Solid Wastes At Residential Dwellings

Waste processing is used to:

1. Reduce the volume,
2. Recover usable materials, or
3. Alter the physical form of the solid wastes.

The most common onsite processing operations used at low-rise detached residential dwellings include food waste grinding, component separation, compaction, incineration (in fireplaces), and composting.

Grinding of Food Wastes

Food waste grinders are used primarily for wastes from the preparation, cooking, and serving of foods. Most grinders sold for home use cannot be used for large bones or other bulky items.

Functionally, grinders render the material that passes through them suitable for transport through the sewer system. Because the organic material added, the wastewater has resulted in overloading many treatment facilities; it has been necessary in some communities to forbid the installation of waste food grinder in new developments until additional treatment capacity becomes available.

Where food waste grinders are used extensively, the weight of waste collected per person will tend to be lower. In terms of the collection operation, the use of home grinders does not have a significant impact on the volume of solid wastes collected. In some cases where grinders are used, it has been possible to increase the time period between collections pickups because wastes that might readily decay are not stored, see figure5.5.

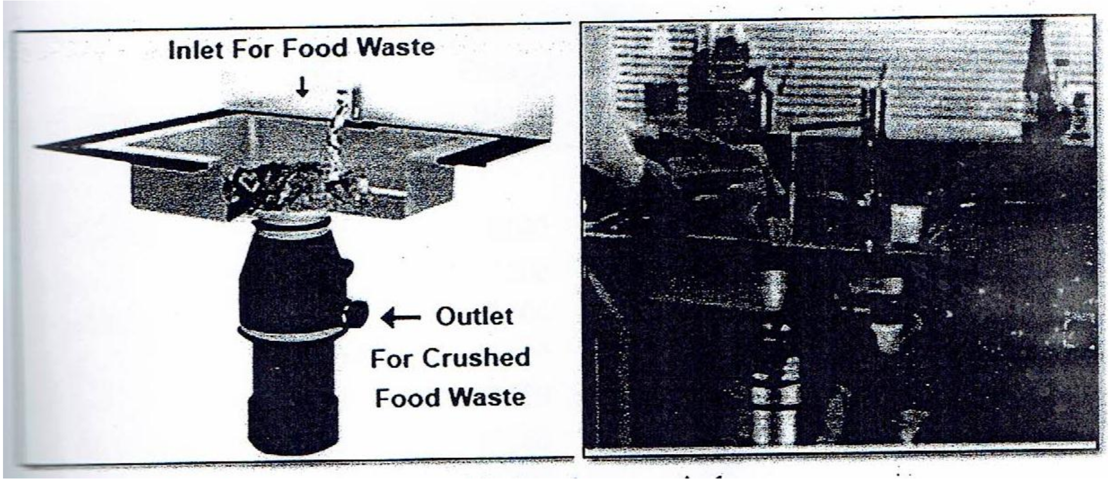

Fig.5.5: kitchen home grinders

Separation of Wastes

The question that must be answered is, what is the energy content of residual solid waste? The effect of home separation on the energy content of the residential MSW is considered in example5.2.

Example5.2: Effect of home separation of waste on energy content of as collected residential MSW. Using the computation table prepared in example3.3(re-produced below), estimate the energy content in Btu/Ib of the remaining solid wastes if 60 percent of the paper and 90 percent of the cardboard are separated by the homeowner.

Component	Solid wastes,[a] lb	Energy,[b] Btu/lb	Total energy, Btu
Organic			
Food wastes	9.0	2,000	18,000
Paper	34.0	7,200	244,800
Cardboard	6.0	7,000	42,000
Plastics	7.0	14,000	98,000
Textiles	2.0	7,500	15,000
Rubber	0.5	10,000	5,000
Leather	0.5	7,500	3,750
Yard wastes	18.5	2,800	51,800
Wood	2.0	8,000	16,000
Inorganic			
Glass	8.0	60	480
Tin cans	6.0	300	1,800
Aluminum	0.5	—	—
Other metal	3.0	300	900
Dirt, ash, etc.	3.0	3,000	9,000
Total	100.0		506,530

[a] From Table1
[b] From Table 2

Solution:

1. The total energy content of 100 Ib of solid waste, with the composition given in Table 2.4 is equal to 505,530 Btu.

2. Determine the energy content and weight of 60 percent of the paper in the original sample.

a. Energy content, 60% pape: $0.60 \times 244{,}800\ Btu = 146{,}880\ Btu$

b. Weight, 60% paper: 0.60 × 34 Ib = 20.4 Ib

3. Determine the energy content and weight of 90 percent of the cardboard in the original sample.

a. Energy content, 90% paper: 0.90 × 42,000 Btu = 37,800 Btu

b. Weight, 90% paper: 0.90 × 6 Ib = 5.4 Ib

4. determine the total energy content, weight, and energy content per pound of the original sample after paper and cardboard have been separated.

a. Total energy after recovery: $(506{,}530 - 146{,}880 - 37{,}800) = 321{,}850\ Btu$

b. Total weight after recovery: $(100 - 20.4 - 5.4) Ib = 74.2\ Ib$

c. Energy content of waste per Ib after separation:

$\frac{321{,}850\ Btu}{74.2\ Ib} = 4338\ \ Btu/Ib\ \ (10{,}090\ \ kJ/kg) versus\ 5065\ Btu/Ib\ (11{,}781\ \ kJ/kg)$

in original sample

Comment: in this example, the removal by weight of approximately 26 percent of the wastes reduced the per-pound energy content of the original sample by approximately 14 percent.

Compaction:

To reduce the volume of solid wastes that must be handled, compaction units commonly are installed in larger apartment buildings. Typically, a compactor is installed at the bottom of a solid, waste chute. Wastes falling through the chute activate the compactor by means of photoelectric cells or limit switches. The compressed wastes may be formed into bales or extruded and loaded automatically into metal containers or paper bags.

Example5.3: Effect of home compactors on volume of collected solid wastes.

Assume that home compaction units are to be installed in a residential area. Estimate the volume reduction that could be achieved in the solid wastes collected if the compacted specific weight is equal to 540 Ib/yd^3 and the data given in Tables 1 and table 3.1 are applicable.

Solution:

1. Set up a computation table to determine the volume of wastes as discarded in containers, using the data given in Table1 and 3.1.

Component	Weight,[a] lb	Specific weight,[b] lb/yd^3	Volume, yd^3 $\times 10^{-2}$
Organic			
Food wastes	9.0	490	1.84
Paper	34.0	150	22.67
Cardboard	6.0	167[c]	3.59
Plastics	7.0	110	6.36
Textiles	2.0	110	1.82
Rubber	0.5	220	0.23
Leather	0.5	270	0.19
Yard wastes	18.5[d]	170	10.88[d]
Wood	2.0[d]	400	0.50[d]
Inorganic			
Glass	8.0	330	2.42
Tin cans	6.0	150	4.00
Aluminum	0.5	270	0.19
Other metal	3.0[d]	540	0.56[d]
Dirt, ash, etc.	3.0[d]	810	0.37[d]
Total	100.0		55.62
			43.31[e]

[a] Data from Table1.
[b] Data from Table3.1.
[c] Cardboard partially compressed by hand before being placed in waste compactor.
[d] Components not usually placed in home waste compactors.
[e] Total excluding components not usually placed in home waste compactors.

2. Determine the volume of compacted wastes, excluding yard wastes; wood; metals other than aluminum and tin cans; and dirt, ashes, etc.

$$Compacted\ volume = \frac{(100 - 18.5 - 2 - 3 - 3)}{540\ Ib/yd^3} = \frac{73.5\ Ib}{540\ Ib/yd^3} = 0.136\ yd^3$$

3. Determine the volume reduction for the compressible material.

$$volume\ reduction = \left(\frac{(0.433 - 0.136)\ yd^3}{0.433\ yd^3}\right) \times 100 = 69\%$$

4. Determine the overall volume reduction achieved with a home compactor, taking into account garden trimmings; wood; metals other than aluminum and tin cans; dirt, ashes, etc.

$$Overall\ volume\ reduction = \left(\frac{0.556\ yd^3 - (0.136 + 0.109 + 0.005 + 0.006 + 0.004)\ yd^3}{0.556\ yd^3}\right) \times 100$$

$$= \left(\frac{0.556\ yd^3 - 0.260}{0.556}\right) \times 100 = 53\%$$

Comment: When the overall volume reduction is assessed, the significance of a home compactor is reduced. This finding is especially true as the percentages of the components not compacted, such as garden trimmings, increase.

Composting:

It is an effective way of reducing the volume and altering physical composition of solid wastes while at the same time producing a useful by- product. A variety of methods are used, depending on the amount of space available and the wastes to be composted. Composting can be a significant factor in the computation to determine the quantity of waste diverted from landfills.

Backyard Composting:

The simplest backyard composting method involves placement of material to be composted in a pile and occasionally watering and turning it to provide moisture and oxygen to the microorganisms within the pile. During composting period, which can take up to year, the material placed in the pile undergo bacterial and fungal decomposition until only a humus material known as compost remains. The composted material, which is biologically stabilized, can be used as a soil amendment or as a mulching material. See figures below.

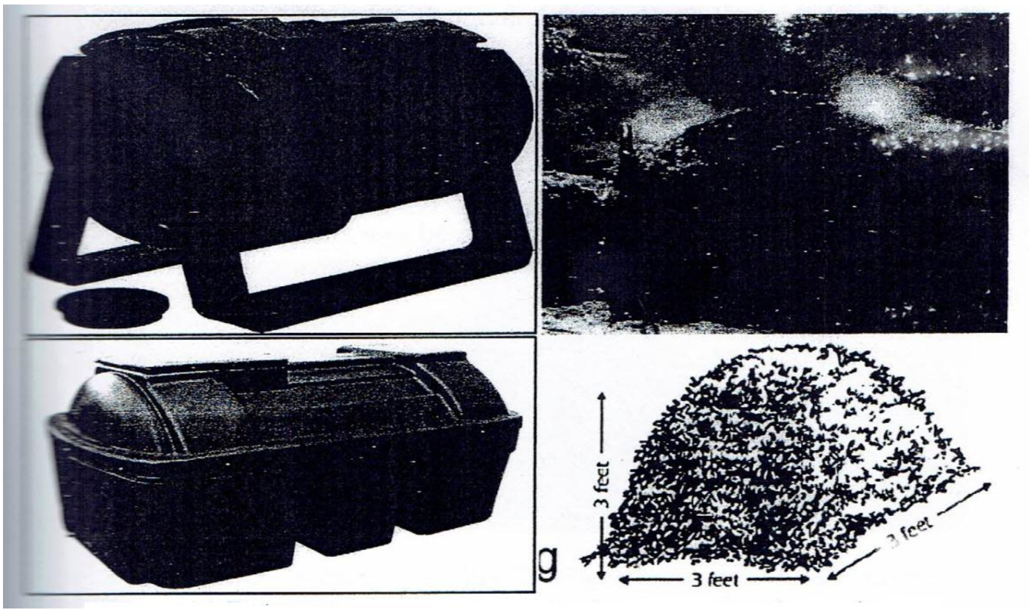

Fig5.6: (a) Rotary and horizontal composter, (b) Composted materials

Combustion:

In the past, the burning of combustible materials in fireplaces and the burn of rubbish in backyard incinerators was common practice. Backyard incinerator is now banned in most parts of the country.

5.4 Processing Of Solid Wastes At Commercial And Industrial Facilities

Onsite processing operations carried out at commercial-industrial facilities generally similar to those described for residential sources.

Compaction:

The baling of waste cardboard at markets and other commercial establishments is quite common. The bales vary in size, baled cardboard is reprocessed for the production of packing materials or shipping overseas for remanufacture into a variety of products.

Shredding and Hydro pulping:

Shredding is used most common in commercial establishments and by governmental agencies to destroy sensitive documents that are no longer of value. In some cases, the volume of wastes has been observed to increase after shredding.

Although hydro pulping systems work well, they are expensive and typically involve discharge to the local wastewater collection system. Because the discharged of pulped material increases the organic loading on local treatment facilities, use of pulverizers may be restricted if treatment capacity is limited.

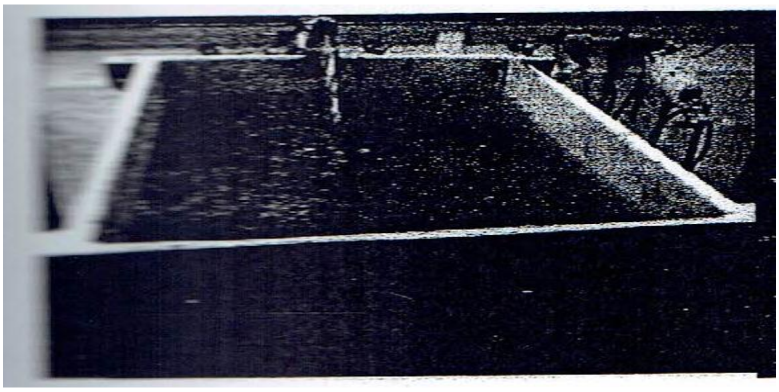

Fig5.7:Hydro pulping

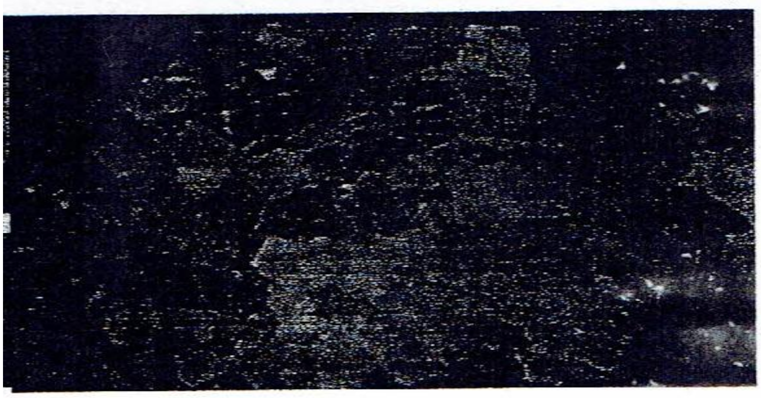

Fig5.8:Paper and cardboard shredding