# Chapter Six

# Disposal of Solid Wastes and Residual Matter

## 1.6 Ultimate Disposal

There are only two alternatives available for the long-term handling of solid wastes and residual matter: disposal on or in the earth's mantle, and disposal at the bottom of the ocean. Disposal on land is by far the most common method in use today. Although disposal in the atmosphere had been suggested as a third alternative, it is not a viable method because material discharged into the atmosphere is ultimately deposited either on the earth or in the sea by a variety of natural phenomena, the most important of which is rainfall.

Ocean dumping of municipal solid wastes was commonly used at the turn of the century and continued until 1933 when it was prohibited.

## 2.6 Sanitary landfill

Means an operation in which, the wastes to be disposed of are compacted and covered with a layer of soil at the end of each day's operation see Figure 1. When the disposal site has reached its ultimate capacity a final layer of 2 ft (0.60 m) or more of cover material is applied.

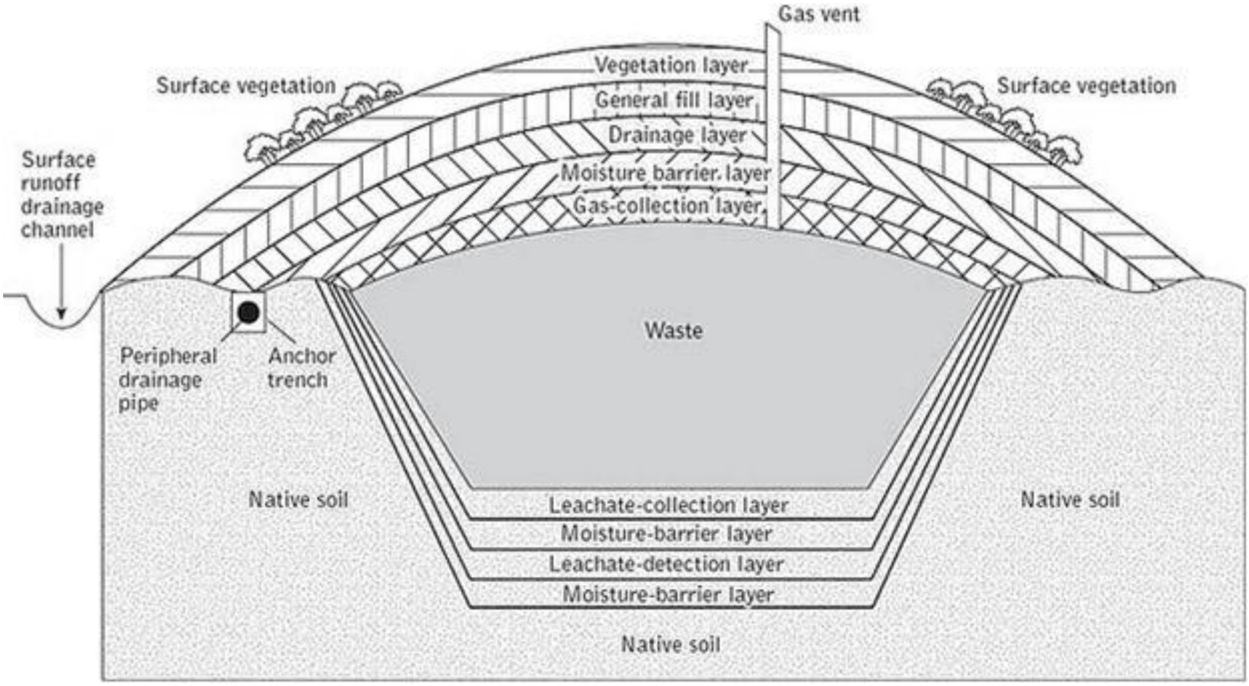



**Figure. 1 Solid waste disposal**

## 3.6 Advantages and disadvantages of sanitary landfill

**Advantages:**

1. Where land is available, a sanitary landfill is usually the most economical method of solid waste disposal.
2. The Initial investment is low compared with other disposal methods.
3. A sanitary landfill is a complete or final disposal method as compared to incineration and composting which require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.
4. A sanitary landfill can receive all types of solid wastes, eliminating the necessity of separate processes.
5. A sanitary landfill is flexible; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.
6. Sub marginal land may be reclaimed for use as parking lots, playgrounds, golf courses, airports, etc.

## 4.6 Disadvantages

1. In highly populated areas, suitable land may not be available within economical hauling distance.
2. Proper sanitary landfill standards must be adhered to daily or the operation may result in an open dump.
3. Sanitary landfills located in residential areas can provoke extreme public opposition
4. A completed landfill will settle and require periodic maintenance
5. Special design and construction must be utilized for buildings constructed on completed landfill because of the settlement factor
6. Methane, an explosive gas. and the other gases produced from the decomposition of the wastes may become a hazard or nuisance and interfere with the use of the completed landfill

## 5.6 Important Aspects in the Implementation of Sanitary Landfills

1. Site selection.
2. Landfilling methods and operations.
3. Occurrence of gases and leachate in landfills.
4. Movement and control of landfill gases and leachate.

## 1.5.6 Site Selection

Factors that must be considered in evaluating potential landfill sites are: (1) available land area, (2 ) impact of processing and resource recovery, (3) haul distance, (4) soil conditions and topography, (5) climatological conditions, (6) surface-water hydrology, (7) geologic and hydrogeologic conditions, (8) local environmental conditions, and (9) potential ultimate uses for the completed site.

تعليمات المحددات البيئية لانشاء المشاريع ومراقبة سلامة تنفيذها رقم (3) لسنة (2011)

المواقع المقترحة لطمر النفايات الصلبة البلدية حسب المادة (24) صنف (ب)

المادة – ٤ ٢ – مواقع الطمر الصحي لنفايات البلدية :المواقع المخصصة للتخلص من النفايات الصلبة غير الخطرة والمتخلفة من جميع الاستعمالات ، ويلزم لانشائها اتباع ما يأتي :

اولا– اقامتها خارج حدود البلدية بمسافة لاتقل عن (٢) كيلومترين و (١) كيلومتر واحد عن التجمعات السكانية وبمسافة لا تقل عن (١) كيلومتر واحد عن محرمات الطريق العام وبموقع مناسب.

ثانيا– العمل وفق الاسس العلمية المتبعة بعمليات الطمر الصحي للنفايات .

ثالثا– تسييج المواقع قبل المباشرة بالاستغلال مع ضرورة تشجير جوانب الموقع قدر المستطاع .

رابعا – انشاء الطرق داخل وخارج الموقع لتسهيل حركة الاليات.

خامسا–توفير المعدات و الاليات اللازمة في عملية الطمر بالطريقة الصحيحة .

سادسا– ترك الموقع بعد ملئه بالنفايات واستخدامه بعد تسوية سطح التربة كمناطق خضراء.

سابعا – معالجة انخفاض سطح التربة بعد مرور فترة مناسبة .

ثامنا – تجهيز الموقع بانابيب لتصريف الراشح المتكون من تحلل النفايات مع تبطين الموقع بمادة غير نفاذة لهذا الراشح .

تاسعا – تجهيز الموقع بانابيب تنفيس الى الجو للغاز الناتج عن التحلل العضوي للنفايات .

### (1) Available land area:-

**Example 1:** Estimate the required landfill area for a community with a population of 31000. Assume that the following conditions apply

1. Solid waste generation is 6.4 1b/ capita/d
2. Compacted density of solid waste in the landfill 8001b/yd$^3$
3. Average depth of compacted solid waste 10ft

**Note:** The actual site requirements will be greater than the value computed, because additional land is required for site preparation, access roads, utilities, etc. Typically, this allowance varies from 20 to 40 percent.

### (2) Impact of processing and resource recovery,

In the initial assessment of potential disposal sites, it is important to project the extent of resource recovery processing activities that are likely to occur in the future and determine their impact on the quantity and condition of the residual materials to be disposed of. For example if 50 percent of the paper were to be recycled, then the landfill area requirement will be reduced. It is also important to know whether the recovery facilities are to be located at the disposal site.

**(3) Haul distance,**

Although minimum haul, distances are desirable. Other factors should be considered in site selection. These include collection route location, local traffic patterns, and characteristics of the routes' to and from the disposal site (condition of the routes traffic patterns, and access conditions).

**(4) Soil conditions and topography,**

Because it is necessary to provide cover material for each day's landfill and a film layer of cover after the filling is completed, data must be obtained on the amount and characteristics of soils in the area of landfilling

**(5) Climatological conditions,**

Where freezing is severe, landfill cover material must be available in stockpiles, because excavation is impractical. Wind and wind patterns must be considered carefully in landfilling site selection. To avoid blowing or flying paper, windbreaks must be established. The specific form of windbreak depends on local conditions. Ideally, prevailing winds should blow toward the filling operation.

**(6) surface-water hydrology,**

The local surface-water hydrology of the area is important in establishing the existing natural drainage and runoff characteristics. Other conditions of flooding must also be identified.

**(7) Geologic and hydrogeologic conditions**

Data on these factors are required to assess the pollution potential of the proposed site and to establish what must be done to the site to ensure that the movement of leachate or gases from the landfill will not impair the quality of local ground water or contaminate other subsurface or bedrock aquifers (see Fig.3).

**8) Local environment conditions,**

While it was possible to build and operate landfill sites in close proximately to both residential and industrial developments extreme care must be taken in their operation if they are to be environmentally acceptable with respect to noise, odor, dust, and vector control. Flying papers and plastic films must also be controlled.

**(9) Potential ultimate uses for the completed site,**

One of the advantages of a landfill is that, once it is completed, a sizable area of land becomes available for other purposes. Because the ultimate use affects the design and operation of the landfill, this issue must be resolved before the layout and design of the landfill are started. For example, if the completed landfill is to be used as a park or golf course, a staged planting program should be initiated and continued as portions of landfilling.

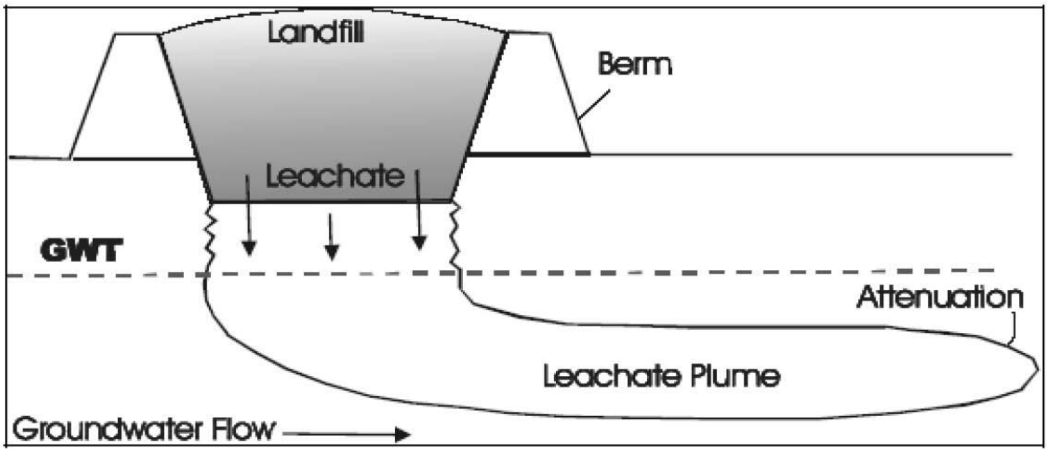



**Figure (3)** Schematic representation groundwater pollution by leachate.

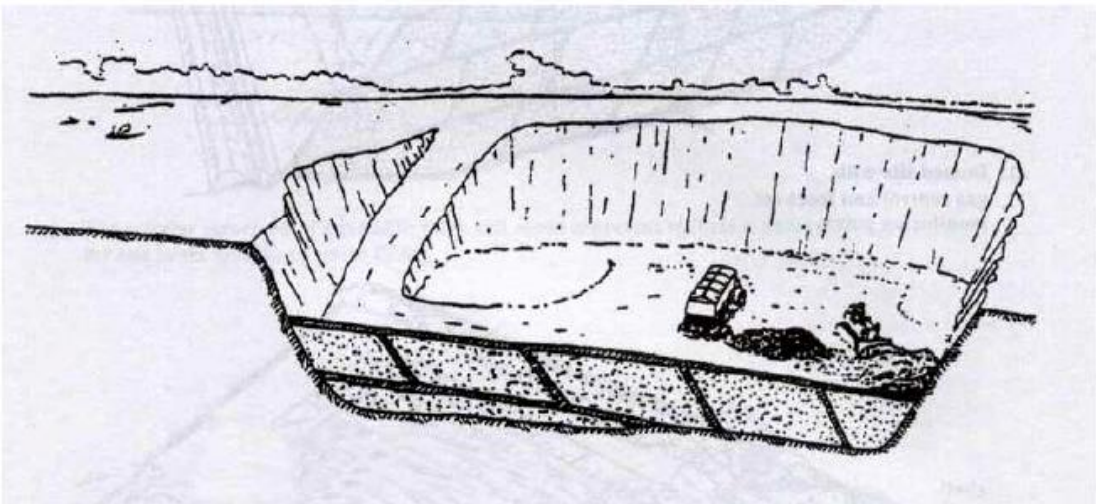
## 7.6 Construction methods for a sanitary landfill

The construction method and subsequent operation of a sanitary landfill are mainly determined by the topography of the terrain, although they also depend on the type of soil and the depth of the water table. There are three basic ways of making a sanitary landfill.

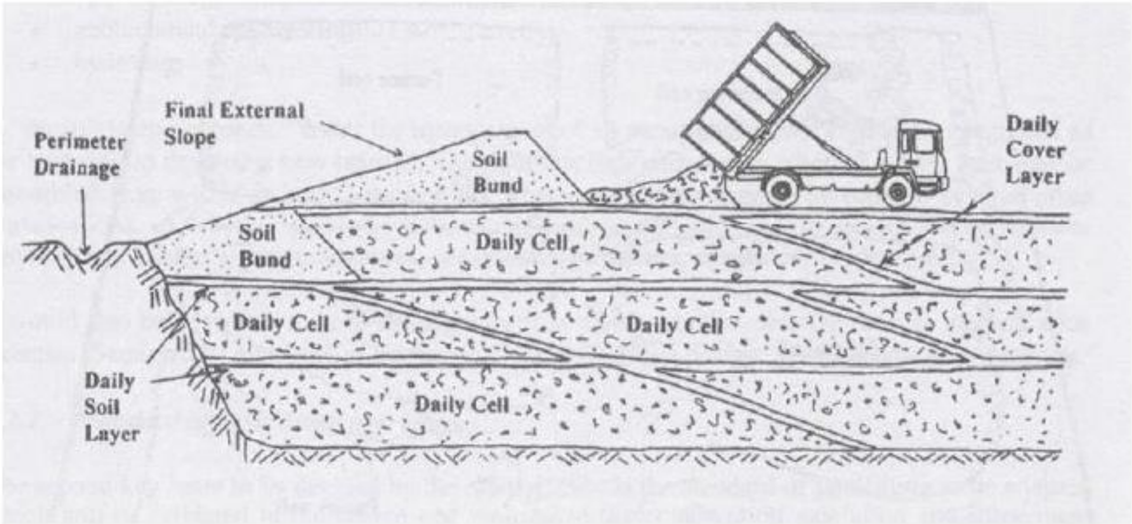
1. Area
2. Trench
3. Depression

**The Area Method**: The filling operation is usually started by building an earthen levee against which wastes are placed in thin layers and compacted. Each layer is compacted as the filling progress until the thickness of the compacted wastes reaches a height varying from 6 to 10 feet (1.83-3.05 m) at that time, at the end of each day operation a 6 to 12in (0.15-0.30 m) layer of cover material is placed over the completed fill. The cover material must be hauled in by truck or earth-moving equipment from adjacent land. A completed lift including the cover is called a cell. Successive lifts are placed on top of one another until the final grade in the ultimate plan is reached. A final layer of cover material is used when the fill reaches the final design height.

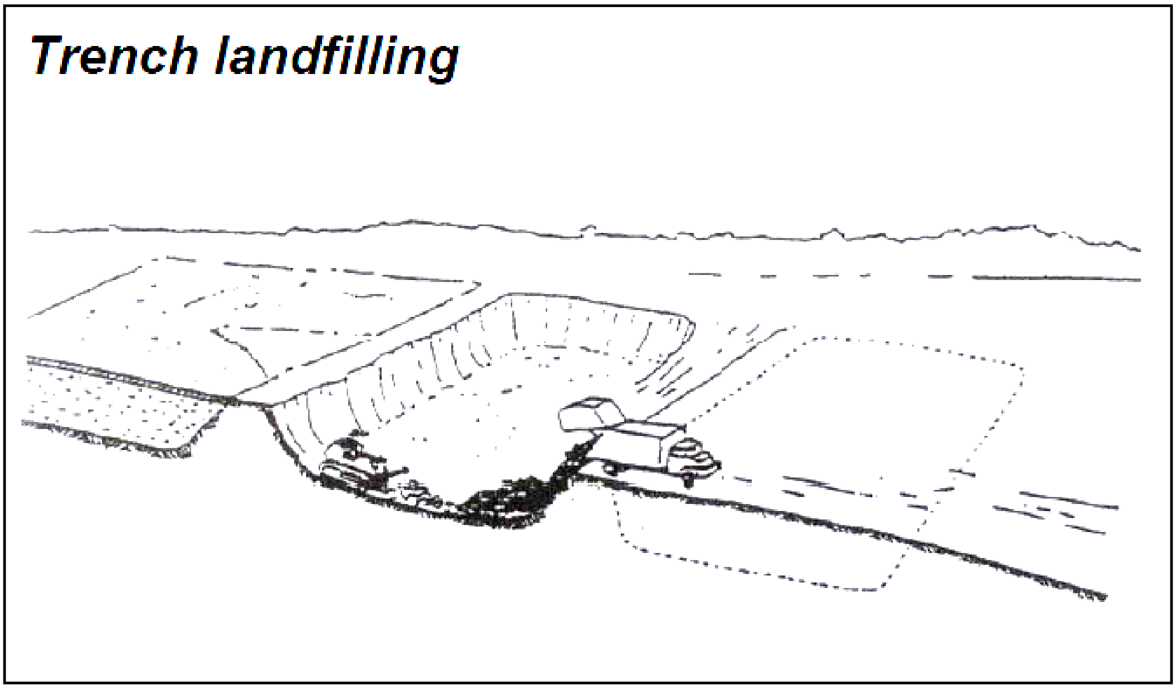
**Area landfilling**



## Daily cover




***The Trench Method***: is ideally suited to areas where an adequate depth of cover material is available and where water table is well below the surface. A portion of the trench is dug with a bulldozer and the dirt is stock piled to form an embankment behind the first trench. Wastes are then placed at the trench spread into thin layers and compacted. The operation continues until the desired level is reached. Cover material is obtained by excavating an adjacent trench



***The Depression Method*:** Where artificial depression occurs, it is often possible to use them effectively for landfilling operations. The techniques to place and compact solid wastes in depression landfills vary with the characteristics of the site. The availability of adequate material to cover the individual lifts and to provide a final cover over the entire landfill is very important. Borrow pits and abandoned quarries may not contain sufficient soil for intermediate cover, so that it may have to be imported.

## 8.6 Reactions occurrence of gases and Leachate in Landfills

The following biological, physical and chemical events occur when solid wastes are placed in a sanitary landfill:

1. Biological decay of organic materials either aerobically or anaerobically, with evaluation of gases and liquids
2. Chemical oxidation of waste materials
3. Escape of gases from the fill
4. Movement of liquids caused by differential heads
5. Dissolving and leaching of organic and inorganic by water and Leachate moving through the fill
6. Movement of dissolved material by concentration gradients and osmosis
7. Uneven settlement caused by consolidation of material into voids.

## 9.6 Decomposition in Landfills

The organic biodegradable components in solid wastes begin to undergo bacterial decomposition as soon as they are placed in a landfill. Initially, bacterial decomposition occurs under aerobic conditions because a certain amount of air is trapped within the landfill. However, the oxygen in the trapped air is soon exhausted, and the long-term decomposition occurs under anaerobic conditions. The principal source of both the aerobic and anaerobic organisms responsible for the decomposition is the soil material that is used as a daily and final cover.

## 10.6 Gases in Landfills

Gases found in landfills include air, ammonia, carbon dioxide, carbon monoxide, hydrogen, hydrogen sulfide methane nitrogen and oxygen. Carbon dioxide and methane are the principal gases produced from the anaerobic decomposition of the organic solid-waste components.

## 11.6 Leachate in Landfills

Leachate may be defined as liquid that has percolated through solid waste and has extracted dissolved or suspended materials from it. The liquid portion of the leachate is composed of the liquid produced from the decomposition of the wastes and liquid that has entered the landfill from external sources, such as rain ground water. The high initial percentage of carbon dioxide is the result of aerobic decomposition. Aerobic decomposition continues to occur until the oxygen in the air initially present in the compacted wastes is depleted. Thereafter, decomposition will proceed anaerobically. After about 18 months, the composition of the gas remains reasonably constant.

## 12.6 Settlement of Landfills

The settlement of landfills depends on the initial compaction, characterization of the wastes, degree of decomposition, and effects of consolidation when the leachate and gases are formed in the landfill. The height of the completed fill will also influence the initial compaction and degree of consolidation. It has been found in various studies that about 90% of ultimate settlement occurs within the first 5 yr. The placement of concentrated loads on completed landfills is not recommended.


### 13.6 Gas Movement

Under ideal condition, the gas generated from a landfill should be either vented to the atmosphere or in larger landfills collected for the production of energy. Over 90% of the gas volume produced from the decomposition of solid wastes consists of methane and carbon dioxide. When methane concentration present in the air between 5-15%, it is explosive. However, there is no oxygen in the landfill when methane concentration in it reach this critical concentration and so there is no danger of explosion

If vented into the atmosphere in an uncontrolled manner methane can accumulate (because its specific gravity is less than that of the air) below buildings or in other enclosed spaces on, or close to a sanitary landfill. With proper venting methane should not pose a problem.

Because $CO_2$ is about 1.5 times as dense as air and 2.8 times as dense as methane, it tends to move toward the bottom of the landfill. As a result the concentration of $CO_2$ at the bottom of the landfill may be high for years.

Ultimately, because of its density carbon dioxide will also move downwards through the under laying formation until it reaches the ground water. Because carbon dioxide is readily soluble in water, it usually lowers the pH which in turn can increase the hardness and mineral content of the ground water through the solubilization of calcium and magnesium carbonates.

$CO_2 + H_2O$ ------- $H_2CO_3$

$H_2CO_3 + CaCO_3$-------$Ca^{+2} + 2H_2CO_3$


## 14.6 Control of Gas Movement

The movement of gases in landfills can be controlled by construction of vents and barriers and by gas recovery

## 15.6 Leachate Movement

Under normal conditions, leachate is found in the bottom of the landfill and will percolate the underlying strata many of chemical and biological constituents originally contained in it will be removed by the filtration and adsorptive action of the material composing the strata.

The use of clay has been the favored method in reducing or eliminating the percolation of leachate. Membrane liners has also been used but they are expensive and require care so that they will not be damaged during the filling operations. The use of appropriate surface slop (1 to 2 percent) and adequate drainage surface infiltration can be used effectively.

**EXA. 1**

Find the amount of land required in a sanitary landfill to dispose of urban waste of city of 40000 in population , knowing that

Amount of waste generation = 2.5 kg/capita/d

density of landfill waste = 500 kg/$m^3$

refuse is filled into a depth of about 3 m.

Sol

2.5 kg/capita/d X 365d X 40000 capita= 36500000 kg total amount of waste

36500000 kg/500 kg/$m^3$ = 73000$m^3$

73000$m^3$ /3m =24333.333 $m^2$ /2500 $m^2$ /donme =9.73 donme

**EXA.2**

Find the amount of land required in a sanitary landfill to dispose of urban waste knowing that:

City population = 176119

Amount of waste generation = 0.875 kg/capita/d

density of landfill waste = 560 kg/$m^3$

refuse is filled into a depth of about 8.5 m.

The landfill site is to be used for 13 years

25% should be added as area necessary for construction facilities

Sol

0.875 kg/capita/d X 176119 =154104 kg/d X 365 =56247960 kg /560 kg/$m^3$

= 100442.78 $m^3$

100442.78 $m^3$ X13 =1305756.1 $m^3$ / 8.5 m =153618.36 $m^2$ /10 000 = 15.3618 Hectares

15.3618 X 0.25 =3.840 Hectares +15.3618 = 19.202 Hectares

**Ex 3**

Determine the density in a well –compacted landfill for solid wastes with the characteristics given in the table below, Density = 1000lb / 28.6 $ft^3$.

| Component | Weight percentages | Weight 1b | Density as discarded 1b/$ft^3$ | Vol. $ft^3$ | Compaction factor | Volume in landfill $ft^3$ |
|---|---|---|---|---|---|---|
| Food waste | 15 | 150 | 18.o | 8.3 | 0.33 | 2.7 |
| Paper | 40 | 400 | 15.1 | 78.4 | 0.15 | 11.8 |
| Cardboard | 4 | 40 | 3.1 | 12.9 | 0.18 | 2.3 |
| Plastics | 3 | 30 | 4 | 7.5 | 0.10 | 0.8 |
| Textile | 2 | 20 | 4 | 5.0 | 0.15 | 0.8 |
| Rubber | 0.5 | 5 | 8 | 0.6 | 0.3 | 0.2 |
| Leather | 0.5 | 5 | 10 | 0.5 | 0.3 | 0.2 |
| Garden trimming | 12 | 120 | 6.5 | 18.5 | 0.2 | 3.7 |
| Wood | 2 | 20 | 15.0 | | 0.3 | 0.4 |
| Glass | 8 | 80 | 12.1 | | 0.4 | 2.6 |
| Tin cans | 6 | 60 | 5.5 | | 0.15 | 1.6 |
| Non ferrous materials | 1 | 10 | 10 | | 0.15 | 0.2 |
| ferrous materials | 2 | 20 | 20 | | 0.3 | 0.3 |
| Dirt, ashes,brick | 4 | 40 | 30 | | 0.75 | 1,0 |
| Total | 100 | 1000 | | 153.4 | | 28.6 |