Module 5Disposal of Solid Waste

Disposal of solid waste; Sanitary land fill- area method, trench method-advantages and disadvantages, Incineration- types of incinerators -parts of an incinerator- incinerator effluent gas composition

STANDARD PROCESSES FOR MANAGING MUNICIPAL WASTE

Incineration: Energy is stored in chemical form in all MSW materials that contain organic compounds i.e. which can be used to generate electricity and steam. It is being done by a few major hospital for managing clinical wastes.

•**Composting**: The natural organic components of MSW (Food and plant wastes, paper, etc) can be composted aerobically to carbon dioxide, water, and a compost product that can be used as soil conditioner. Anaerobic digestion or fermentation produces methane, alcohol and a compost product.

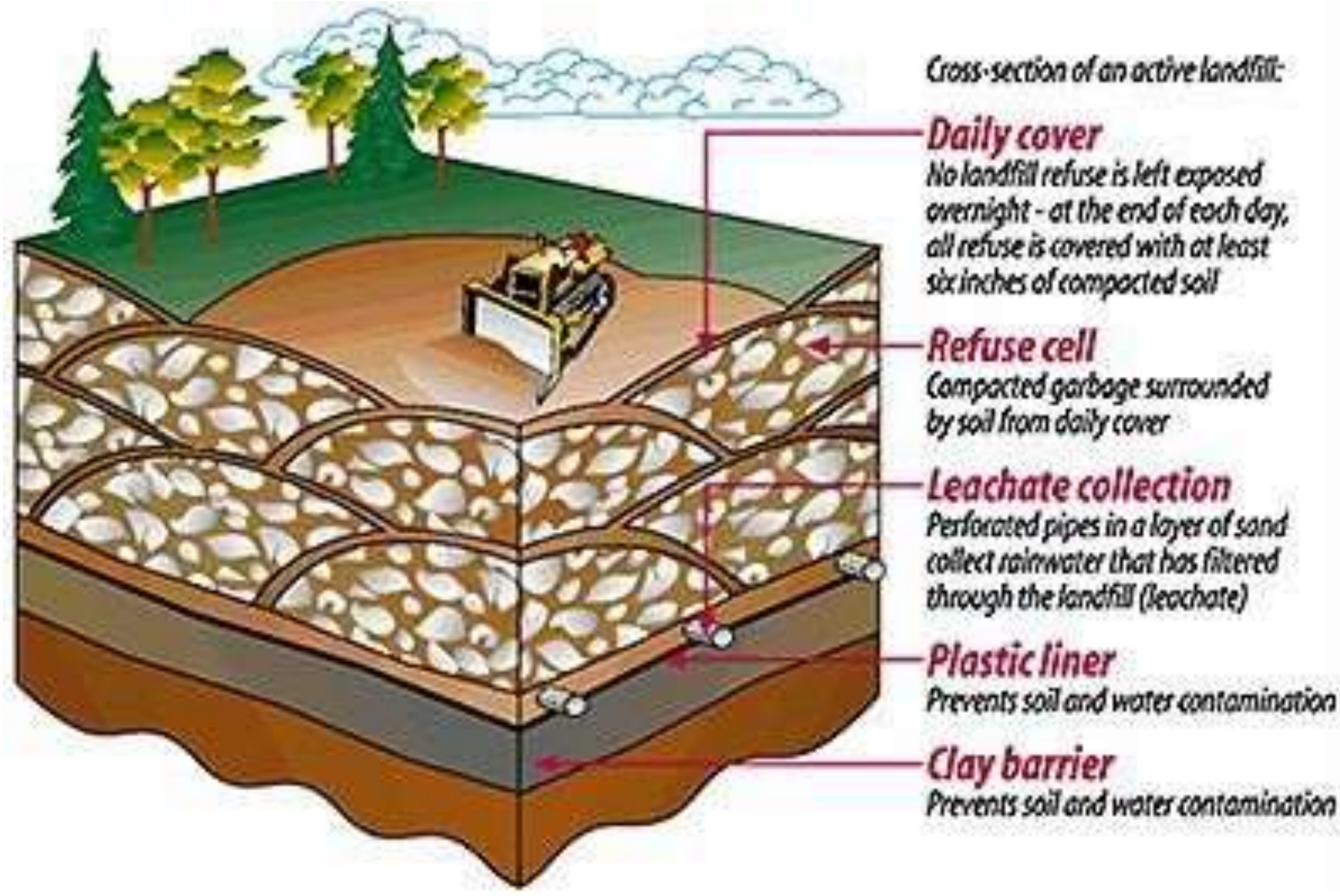
•**Recovery/recycling**: Recovered paper, plastic, metal, and glass can be re- used. In the absence of formalized waste segregation practices, recycling has emerged only as an informal sector using outdated technology, which causes serious health problems to waste–pickers

•**Land filling**: MSW materials that cannot be subjected to any of the above three method, plus any residuals from these processes (e.g. ash from combustion) must be disposed in properly desinged landfills.

Landfill

- A landfill is an engineered method for land disposal of solid or hazardous wastes in a manner that protects the environment.
- Within the landfill biological,chemical, and physical processes occur that promote the degradation of wastes and result in the production of leachate (polluted water emanating from the base of the landfill) and gases.

Landfill



Cross-section of an active landfill:
Daily cover
No landfill refuse is left exposed overnight - at the end of each day, all refuse is covered with at least six inches of compacted soil
Refuse cell
Compacted garbage surrounded by soil from daily cover
Leachate collection
Perforated pipes in a layer of sand collect rainwater that has filtered through the landfill (leachate)
Plastic liner
Prevents soil and water contamination
Clay barrier
Prevents soil and water contamination

Sanitary Landfill

- *sanitary landfill* refers to an engineered facility for the disposal of MSW designed and operated to minimize public health and environmental impacts.
- Landfills for individual waste constituents such as combustion ash, asbestos, and other similar wastes are known as *monofills.*
- Landfills for the disposal of hazardous wastes are called
  secure landfills.
- Those places where waste is dumped on or into the ground in no organized manner are called *uncontrolled land disposal sites* or *waste dump*

Sanitary Landfill-Methods

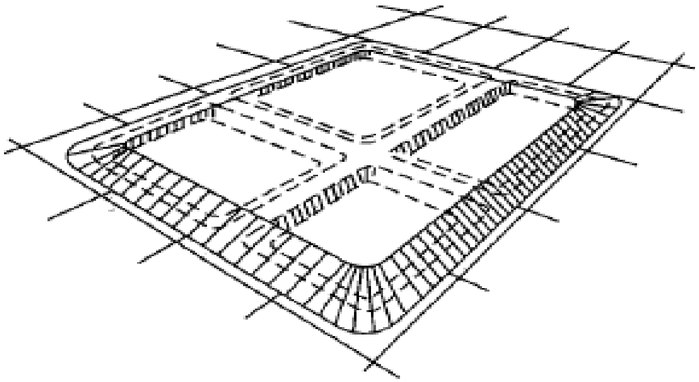
The principal methods used for the landfilling of MSW may be classified as

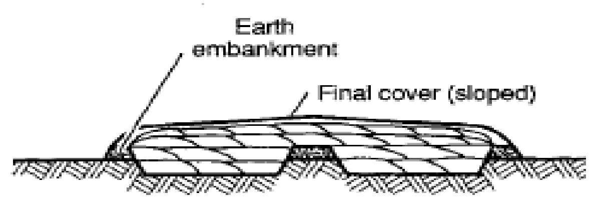
(1) excavated cell/trench Method,

(2) area method

(3) canyon.

Excavated cell/trench Method

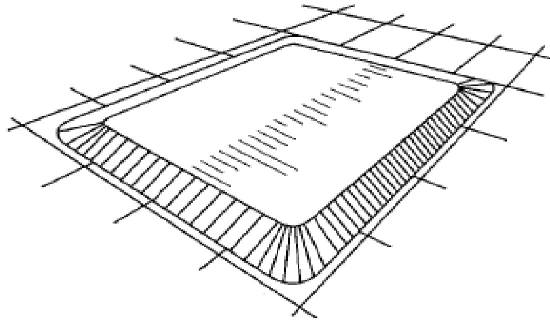


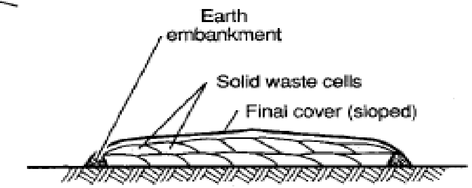


Excavated cell/ Trench method-

1. Ideally suited to areas where an adequate depth of cover material is available at the site and water table is not near the surface.
2. MSW are placed in cells/ trenches excavated in the soil.
3. Soil excavated from the site is used for daily and final cover.
4. Excavated cells are lined with synthetic membrane liners/ low permeability clay/combination of two to limit the movement of landfill gas and leachate.

Area Method





1. Used when terrain is unsuitable for excavation of cells/ trenches and GW table is high.
2. Site preparation includes installation of liners and leachate management system.
3. Cover material must be obtained from adjacent land/ burrow, pit areas.
4. Since there is limited material for covering, compost, foundry sand has been utilized as intermediate cover material.
5. Temporary cover material of soil and geosynthetic blankets placed temporarily over completed cell and removed before next lift is began.
6. Leachate generation may occur and may be difficult to control.

Advantages of Landfilling

- Incineration is a costly process, residue requires ultimate disposal on land.
- Composting is a seasonal option.
- It is not possible to reclaim and recycle all SW material.
- Thus landfilling is the most convenient option.

Disadvantages

- Difficult to find suitable site within economically feasible distance.
- It is not possible to build a completely safe and secure SW landfill.
- Some of the pollutants may escape in the environment in the form of leachate.
- Potential harm to public health due to air, soil, water and noise pollution
- Damage to local ecosystem.
- Public oppose

Incineration

- Waste-to-energy combustion is an important technology for municipal solid waste management.
- But its growth has recently slowed while communities wrestle with issues that range from flow control to impact on recycling to cost effectiveness, and to political acceptability.
- **Nevertheless, waste-to-energy combustion can be an important factor in an overall fully integrated solid waste management strategy.The traditional term *incineration* has acquired a bad connotation in the mind of the public due to the poor operation of some waste combustors in the past.**

Advantages

- The technology offers great opportunities for reducing the volume of waste to be landfilled, as well as for generating heat and power.
- Raw solid waste has a heating value between 8000 and 14000 KJ/Kg compared to coal, which releases about 240,00KJ/Kg. Hence, a large amount of heat can be released by burning municipal waste, and that heat can be used to generate electric power.
- It has been estimated that waste-to-energy facilities could supply as much as 2 percent of the electrical power needed in this country. But, more important, incineration reduces the volume of waste dramatically, up to tenfold. Thus, incineration can be attractive.
- **The major constraints on waste-to-energy combustion facilities are their cost, the level of sophistication needed to operate them safely.The public is concerned about stack emissions of dioxins and the toxicity of ash residues.**

Advantages

1. The volume and weight of the waste are reduced to a fraction of their original size.
2. Waste reduction is immediate; it does not require long-term residence in a landfill or holding pond.
3. Waste can be incinerated on-site, without having to be carted to a distant area.
4. Air discharges can be effectively controlled for minimal impact on the atmospheric environment.
5. The ash residue is usually nonputrescible, or sterile
6. Technology exists to completely destroy even the most hazardous of materials in a complete and effective manner.
7. Incineration requires a relatively small disposal area, compared to the land area required for conventional landfill disposal.
8. By using heat-recovery techniques the cost of operation can often be reduced or offset through the use or sale of energy.

Disadvantages

Incineration will not solve all waste problems. Some **disadvantages** include:

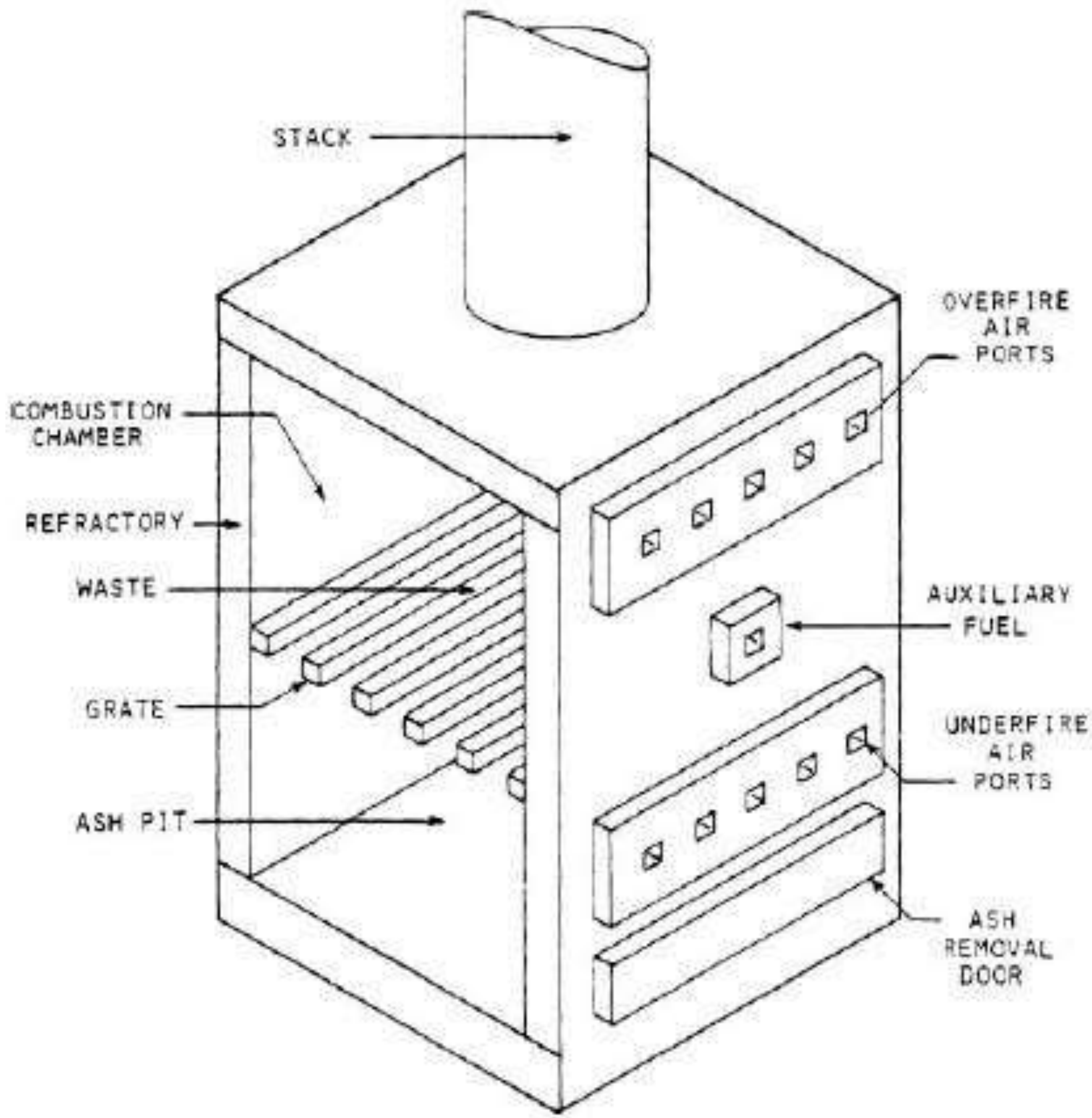
1. The capital cost is high.
2. Skilled operators are required.
3. Not all materials are incinerable (e.g., construction and demolition wastes).
4. Supplemental fuel is required to initiate and at times to maintain the incineration process.

Types of Solid Waste Incinerators

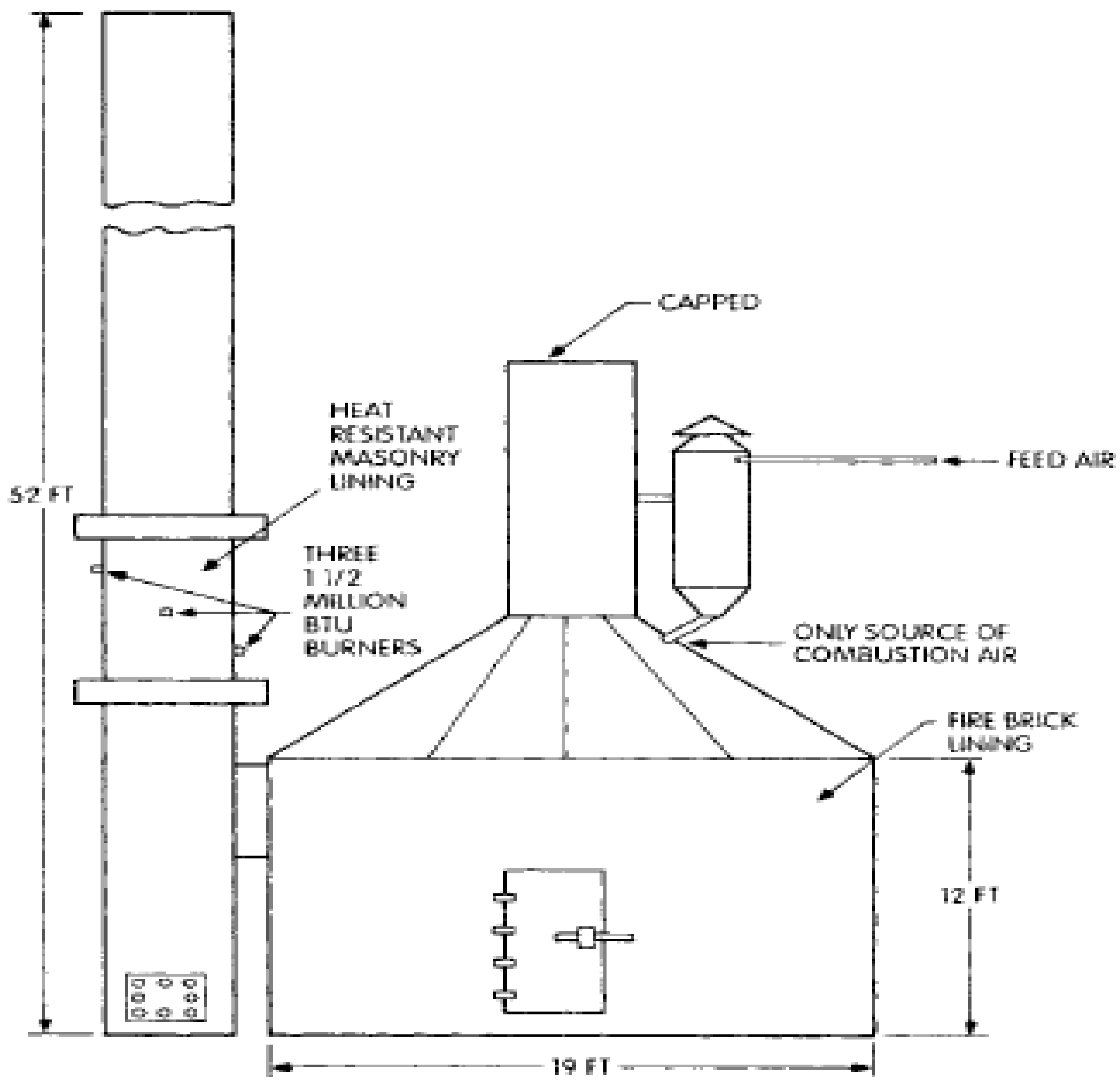
Waste incineration includes the following techniques:

1. Open burning
2. Single-chamber incinerators
3. Tepee burners
4. Open-pit incinerators
5. Multiple-chamber incinerators
6. Controlled air incinerators
7. Central-station disposal
8. Rotary kiln incinerators

Parts of an incinerator-Single-chamber incinerator



Parts of an incinerator-Modified jug Incinerator



MODULE 5

DISPOSAL OF SOLID WASTE

There are three alternatives available for the long term handling of solid wastes and residual matter,

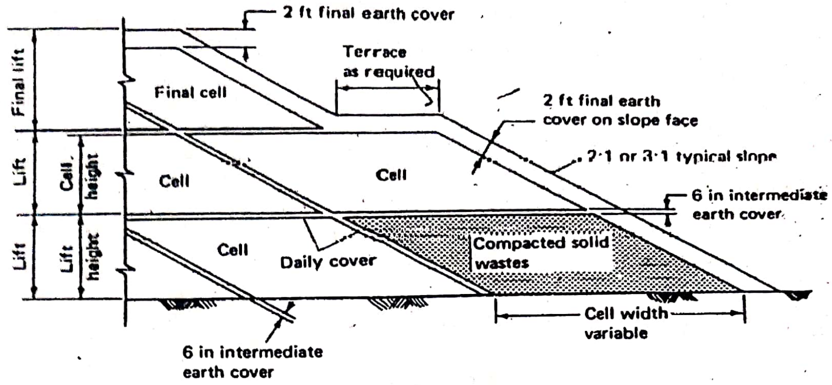
- Disposal on or in the earth's mantle
- Disposal at bottom of ocean
- Disposal above atmosphere

Disposal on land is the most common and economic method. This can be done by

- Sanitary landfill
- Incineration
- Composting

SANITARY LANDFILL

The term 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 days operation. When the disposal site has reached its ultimate capacity a final layer of 2 ft or more of cover material is applied.



Sectional view of a sanitary landfill.

Advantages and disadvantages of sanitary Landfill

ADVANTAGES AND DISADVANTAGES OF SANITARY LANDFILL*

Advantages	Disadvantages
1. Where land is available, a sanitary landfill is usually the most economical method of solid waste disposal.	1. In highly populated areas, suitable land may not be available within economical hauling distance.
2. The initial investment is low compared with other disposal methods.	2. Proper sanitary landfill standards must be adhered to daily or the operation may result in an open dump.
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.	3. Sanitary landfills located in residential areas can provoke extreme public opposition.
4. A sanitary landfill can receive all types of solid wastes, eliminating the necessity of separate collections.	4. A completed landfill will settle and require periodic maintenance.
5. A sanitary landfill is flexible; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.	5. Special design and construction must be utilized for buildings constructed on completed landfill because of the settlement factor.
6. Submarginal land may be reclaimed for use as parking lots, playgrounds, golf courses, airports, etc.	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.

Site selection

Factors that must be considered in evaluating potential solid waste disposal sites include (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.

(1) Available land area

In selecting potential land disposal sites, it is important to ensure that sufficient land area is available. Although there are no fixed rules concerning the area required, it is desirable to have sufficient area to operate for at least 1 yr at a given site. For shorter periods, the disposal operation becomes considerably more expensive, especially with respect to site and preparation, provision of auxillary facilities

(2) Impact of resource recovery

In the initial assessment of potential dispos sites, it is important to project the extent of resources 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.

(3) Haul distance

The haul distance is one of the important variable in the selection of disposal site. Although minimum haul distance are desirable, other factors must also be considered. These include collection route location, local traffic patterns and characteristics of the routes to and from the disposal site.

(4) Soil condition

It is necessary to provide cover material for each day's landfill and a final layer of cover after the filling is completed. data must be obtained on the amounts and characteristics of the soils in the area. If the soil under the proposed landfill area is to be used for cover material, data will be available from geologic and hydrogeologic investigation. If cover material is ~~to be~~ obtained from borrow pit, test borings will be needed to characterize the material adequately.

The local topography must be considered because it will affect the type of landfill operation to be used, the equipment requirements, the extent of work.

(5) Climatologic conditions

Climatologic Conditions

Local weather conditions must also be considered in the evaluation of potential sites. In many locations, access to the site will be affected by winter conditions. Where freezing is severe, landfill cover material must be available in stockpiles when excavation is impractical. Wind and wind patterns must also be considered carefully. To avoid blowing or flying papers, windbreaks must be established. The specific form of windbreak depends on local conditions. Ideally, prevailing winds should blow toward the filling operation.

(6) **Local Environmental Conditions**

While it has been possible to build and operate landfill sites in close proximity 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.

(7) **Surface-Water Hydrology**

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

(8) **Geologic and Hydrogeologic Conditions**

Geologic and hydrogeologic conditions are perhaps the most important factors in establishing the environmental suitability of the area for a landfill site. 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 groundwater or contaminate other subsurface or bedrock aquifers. In the preliminary assessment of alternative sites, it may be possible to use United States Geological Survey maps and state or local geologic information. Logs of nearby wells can also be used.

(9) **Ultimate Uses**

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 large, open structures (such as a warehouse) are to be built, footing locations must be established and allowances made for them. 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 the landfill are completed.

sizable
ultimate

LANDFILLING METHODS

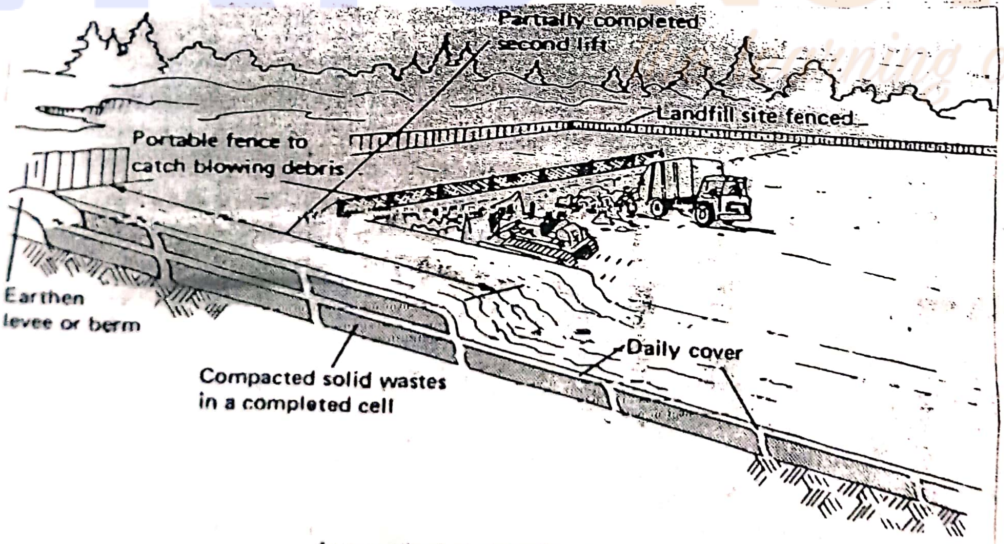
To use the available area at a landfill site effectively, a plan of operation for the placement of solid wastes must be prepared. Various operational methods have been developed primarily on the basis of field experience. The methods used to fill dry areas are substantially different from those used to fill wet areas.

Conventional Methods for Dry Areas

The principal methods used for landfilling dry areas may be classified as (1) area, (2) trench, and (3) depression. In addition to these methods, which usually are used for unprocessed municipal solid wastes, landfilling using milled (shredded) solid wastes is also discussed.

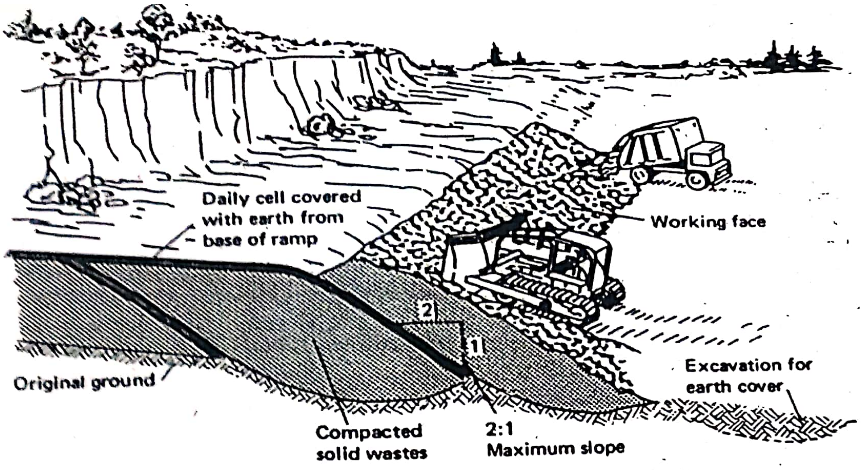
Area Method The area method is used when the terrain is unsuitable for the excavation of trenches in which to place the solid wastes. Operationally (see Fig. 10-3) the wastes are unloaded and spread in long, narrow strips on the surface of the land in a series of layers that vary in depth from 16 to 30 in. Each layer is compacted as the filling progresses during the course of the day until the thickness of the compacted wastes reaches a height varying from 6 to 10 ft. At that time, and at the end of each day's operation, a 6- to 12-in 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 or from borrow-pit areas.

The filling operation usually is started by building an earthen levee against which wastes are placed in thin layers and compacted. The length of the unloading area varies with the site conditions and the size of the operation. The width over which the wastes are compacted varies from 8 to 20 ft, again depending on the terrain. A completed lift, including the cover material, is called a *cell*. Successive lifts are placed on top of one another until the final grade is reached that was called for in the ultimate development plan. The length of the unloading area used each day should be such that the final height of the fill is reached at the end of each day's operation.



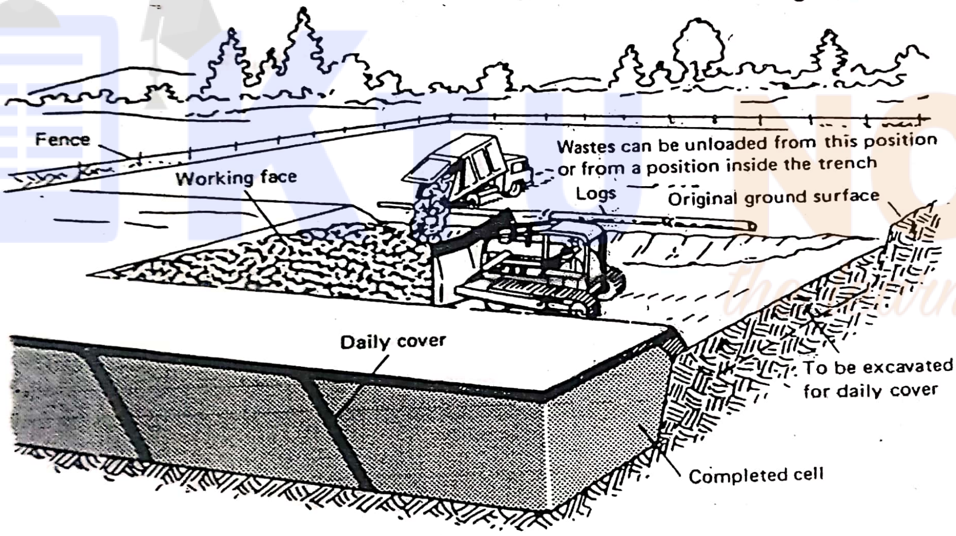
Area method of operation for a sanitary landfill.

If a small amount of usable cover material is available at the disposal site, the ramp variation of the area method is often used (see Fig. 10-4). In this method, solid wastes are placed and compacted as described for the area method and are partially or wholly covered with earth scraped from the base of the ramp. Additional soil must be hauled in, as in the area method. Because of increasing costs and the problems associated with obtaining usable cover material, the use of the ramp method must be based on a detailed economic feasibility study.



Ramp method of operation for a sanitary landfill.

2\. Trench Method The trench method of landfiling is ideally suited to areas where an adequate depth of cover material is available at the site and where the water table is not near the surface. Typically, solid wastes are placed in trenches varying from 100 to 400 ft in length, 3 to 6 ft in depth, and 15 to 25 ft in width. To start the process, a portion of the trench is dug and the dirt is stockpiled to form an embankment behind the first trench. Wastes are then placed in the trench, spread into thin layers (usually 18 to 24 in), and compacted. The operation continues until the desired height is reached. The length of trench used each day should be such that the final height of fill is reached at the end of each day's operation. The length also should be sufficient to avoid costly delays for collection vehicles waiting to unload. Cover material is obtained by excavating an adjacent trench or continuing the trench that is being filled.



Trench method of operation for a sanitary landfill.

3\. Depression Method At locations where natural or artificial depressions exist, it is often possible to use them effectively for landfilling operations. Canyons, ravines, dry borrow pits, and quarries have all been used for this purpose. The techniques to place and compact solid wastes in depression landfills vary with the geometry of the site, the characteristics of the cover material, the hydrology and geology of the site, and the access to the site.

If a canyon floor is reasonably flat, the first fill in a canyon site may be carried out using the trench method/operation. Once filling in flat area has been completed, filling starts at the head end of the canyon and ends at the mouth. Wastes usually are deposited on the canyon floor and from the pushed up against the canyon face at a sl... of about 2 to 1. compacted densities is hi... as 1,200 lb/yd^3. (Fig. 10.6.)

ii Conventional methods for wet areas

Swamps and marshes, tidal areas, ponds, pits or quarries are typical wet areas that have been used as landfill sites. Because of the problems associated with contamination of local groundwaters, development of odours, structural stability, the design of landfill in wet areas requires special attention.

In the past, landfilling in wet areas was considered acceptable if reasonably adequate drainage were provided and if nuisance conditions did not develop. The usual practice was to divide the area into cells or lagoons 1
and to schedule the filling operations so that one individual cell or lagoon would be filled each year. Often, solid wastes were placed directly in the water in areas with high groundwater levels. As an alternative, clean fill 2
material was added up to, or slightly above, the water level before waste filling operations were started.

To withstand mud waves and to increase structural stability, dikes 3
used to divide the cells or lagoons were constructed with riprap, trees, tree limbs, lumber, demolition wastes, and related materials in addition to clean fill material. In some cases, to prevent the movement of malodorous leachate and gases from completed cells or lagoons, clay and lightweight 4
interlocking steel or wood-sheet piling have been used.

More recently, because of concern over the possibility of groundwater contamination by both leachate and gases from landfills and the development of odors, the direct filling of wet areas is no longer considered acceptable. If wet areas are to be used as landfill sites, special provisions must be made to contain or eliminate the movement of leachate and gases from completed cells. Usually this is accomplished by first draining the site 5
and then lining the bottom with a clay liner or other appropriate sealants. If a clay liner is used, it is important to continue operation of the drainage facility until the site is filled in order to avoid the creation of uplift pressures that could cause the liner to rupture from heaving.

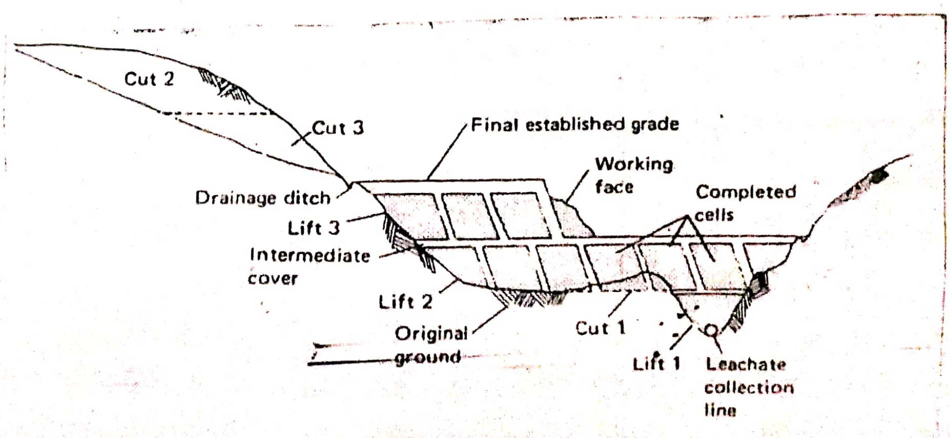


FIG. 10-6 Landfilling in a canyon or ravine.

10-3 REACTIONS OCCURRING IN COMPLETED LANDFILLS

To plan and design sanitary landfills effectively, it is important to understand what takes place within a landfill after filling operations have been completed. Solid wastes placed in a sanitary landfill undergo a number of simultaneous biological, physical, and chemical changes. Among the more important of these changes are the following: (1) the biological decay of organic putrescible material, either aerobically or anaerobically, with the evolution of gases and liquids; (2) the chemical oxidation of materials; (3) the escape of gases from the fill and lateral diffusion of gases through the fill; (4) the movement of liquids caused by differential heads; (5) the dissolving and leaching of organic and inorganic materials by water and leachate moving through the fill; (6) the movement of dissolved material by concentration gradient and osmosis; and (7) the uneven settlement caused by consolidation of material into voids [24]. The decomposition and stabilization in a landfill depend on many factors, such as the composition of the wastes, the degree of compaction, the amount of moisture present, the presence of inhibiting materials, the rate of water movement, and temperature.

Because of the number of interrelated influences, it is difficult to define the conditions that will exist in any landfill or portion of a landfill at any stated time. In general, it may be said that the rates of chemical and biological reactions in a sanitary landfill increase with the temperature and the amount of moisture present until an upper limit is reached in each instance

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 the anaerobic organisms responsible for the decomposition is the soil material that is used as a daily and final cover.

The overall rate at which the organic materials decompose depends on their characteristics and, to a large extent, on the moisture content. In general, the organic materials present in solid wastes can be divided into three major classifications: (1) those that contain cellulose or derivatives of cellulose; (2) those that do not contain cellulose or cellulose derivatives; and (3) plastics, rubber, and leather.

Cellulose is a major constituent of organic wastes, such as paper, rags, string, straw, and plant tissues. With the exception of plastics, the principal noncellulose organics are proteins, carbohydrates, and fats. Mineral salts in very limited quantities and moisture are almost always associated with these materials. Plastics that may be found in solid wastes are so many and so varied that no general list is possible in this text.

With the above wastes, the principal end products of anaerobic decomposition are partially stabilized organic materials, intermediate volatile organic acids, and various gases (including carbon dioxide, methane, nitrogen, hydrogen, and hydrogen sulfide). Under normal conditions the rate of decomposition, as measured by gas production, reaches a peak within the first 2 yr and then slowly tapers off, continuing in many cases for periods up to 25 yr or more. If moisture is not added to the wastes in a well-compacted landfill, it is not uncommon to find materials in their original form years after they were buried.

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. 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 ... Thereafter, decomposition will proceed anaerobically

INCINERATION

The various constituents of solid waste give it a good thermal value. When solid waste is completely burnt, heat energy is released. The residue after combustion requires less volume and is hygienic to handle. Different types of incinerators are used for this purpose.

It is the process of direct burning of waste in the presence of excess air at 800^0C and above, liberating heat energy, inert gas and ash. In practice, about 65 to 80% of the energy content of the organic matter can be recovered as heat energy and used for power production by steam turbine generators. Incineration process produces the following gases,

- CO_2
- CO
- O_2
- N_2O and H_2O
- SO_2 and
- Final ash

Advantages of incineration

- Requires less space than other methods
- Plant can be located in city area, so cost of transportation can be reduced
- Reduce volume by 90% or $1/10^{th}$ of initial volume
- Large heat energy is recovered and used for electricity generation
- Stabilization and sterilization of wastes and destructs pathogens.

TYPES OF INCINERATORS

A. Based on the purpose

i. *Domestic*

These are incinerators having low capacity, upto 50 kg/hr.

ii. *Commercial*

These are incinerators having medium capacity, 50 kg/hr to 500 kg/hr.

iii. *Municipal*

These are incinerators having high capacity, above 50 kg/hr.

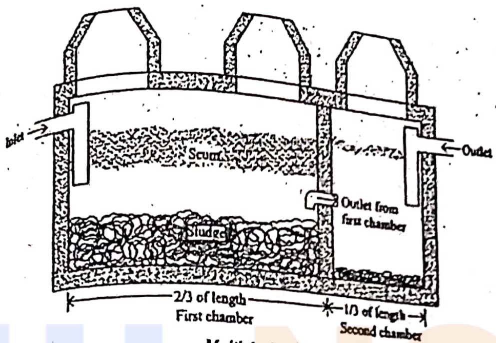
B. Based on number of chambers

i. *Single chamber*

These are insufficient in ensuring complete combustion of solid waste.

ii. *Multi chamber*

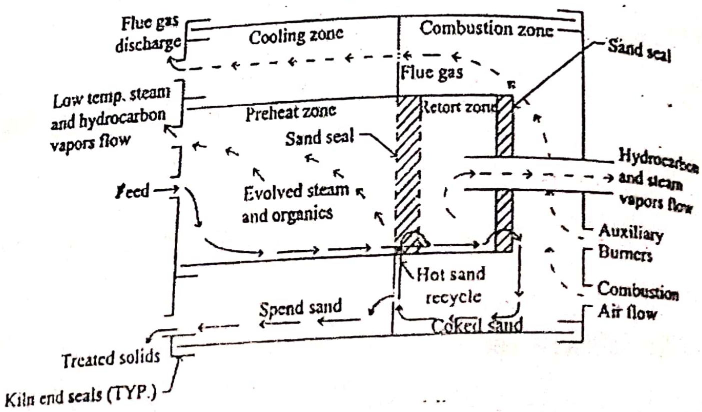
Solid waste is fed into primary combustion chamber where it is dried and ignited. The moisture and volatile components of the wastes are vaporized. The gaseous products then pass through flame port, where at high flue gas velocity the volatile matters burns. The product is then passed to the mixing chamber, where fresh air is mixed for O_2 supply for complete oxidation. Finally the combustion is completed in the secondary chamber. The flue escapes to the atmosphere through the chimney.



Multiple Chamber Incinerator

a. Retcot type

This is preferred at < 350 kg/hr. the arrangement of chambers is such that gases change direction by 90° both in lateral and vertical direction. Due to return flow of gases, a common wall is used between 10 and 2 0 chamber. Mixing chamber flame ports and curtain wall ports have length of width ratios of 1:1 to 2.4:1. The thickness of bridge wall under the flame port is a function of dimensional requirements in the mixing and combustion chambers are widely used for large capacities.



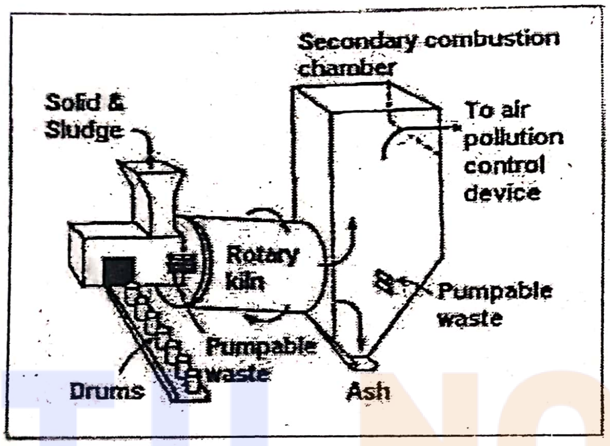
b. Inline type

The gases take 90° turn only in vertical direction. All ports and chambers extend across the full width of the incinerators. Mixing chamber, flame ports and curtain wall ports have length to width ratios of 2:1 to 5:1.

C. Based on technologies

i. Mass burning system

This is the widely used type. It consists of a reciprocating grate combustion system and a refractory which is lined and a water walled steam generator. They have 2 or 3 chambers with 50 to 100 tonnes/day capacity. Example is inline incinerators.



ii. Refuse derived fuel system

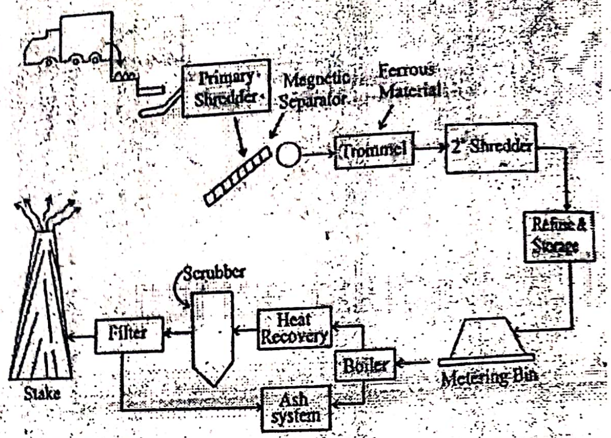
The term RDF is commonly used to refer to solid waste that has been mechanically processed to produce a storable, transportable and more homogeneous for combustion. It use any form of solid waste as fuel. RDF system have 2 components:

a. RDF production

RDF production makes RDF in various forms through material separation, size reduction and pelletising.

b. RDF incineration

Once the waste is loaded on the conveyor, the waste travels through a number of processing stages, usually beginning with magnetic separation.



Flow Diagram - Refuse Derived Fuel

iii. *Modular incineration*

Modular incinerator units are usually prefabricated units with relatively small capacities between 5 and 120 tonnes of solid waste per day. Typical facilities have between 1 and 4 units with a total plant capacity of about 15 to 400 tonnes per day. The majority of modular units produce steam as the energy product. Due to their small capacity, modular incinerators are generally used in small communities or for commercial and industrial operations.

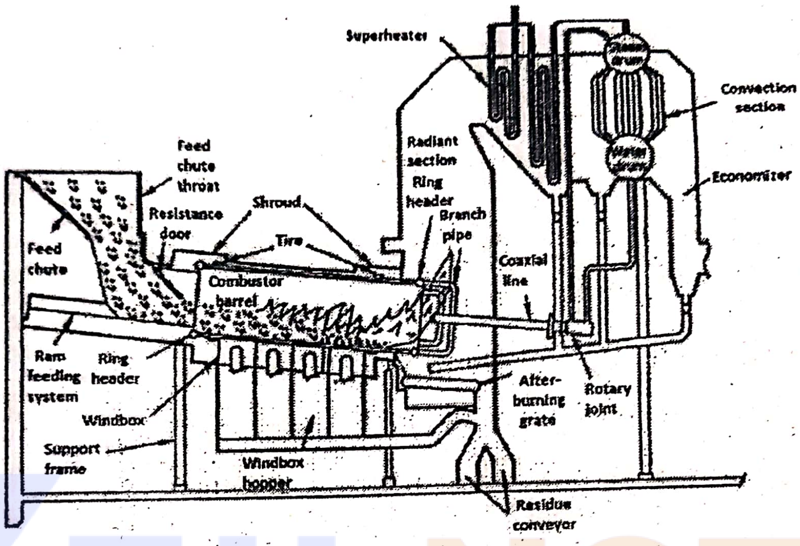
Their prefabricated design gives modular facilities the advantage of a shorter construction time. Modular combustion systems are usually factory-assembled units consisting of a refractory-lined furnace and a waste heat boiler. Units can be pre-assembled and shipped to the construction site, which minimises field installation time and cost. Adding modules or units, installed in parallel can increase facility capacity. The boilers are built in a factory and shipped to the plant site, rather than being erected on the site, as in case with larger plants.

Modular incinerators employ a different process from that of mass-burn incinerators, typically involving two combustion chambers, and combustion is typically achieved in two stages.

- The first stage may be operated in a condition in which there is less than the theoretical amount of air necessary for complete combustion. The controlled air condition creates volatile gases, which are fed into the secondary chamber, mixed with additional combustion air, and under controlled conditions, completely burned.
- Combustion temperatures in the secondary chamber are regulated by controlling the air supply, and when necessary, through the use of an auxiliary fuel. The hot

combustion gases then pass through a waste heat boiler to produce steam for electrical generation or for heating purposes.

The combustion gases and products are processed through air emission control equipment to meet the required emission standards. In general, modular incineration systems are a suitable alternative for smaller-sized facilities, be more cost-effective than other incinerators. But modular incineration has become less common, partly due to concerns over the consistency and adequacy of air pollution controls.



iv. *Fluidized bed incineration*

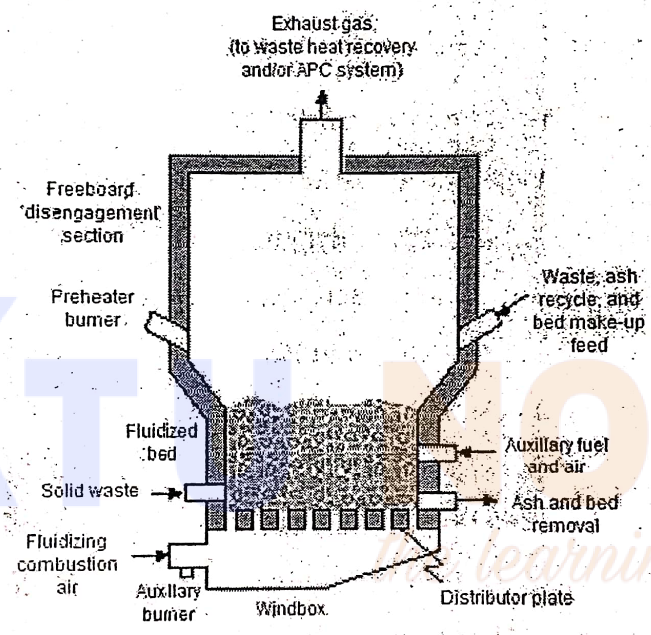
Fluidised-bed incineration of MSW is typically medium scale, with processing capacity from 50 to 150 tonnes per day. In this system, a bed of limestone or sand that can withstand high temperatures, fed by an air distribution system, replaces the grate. The heating of the bed and an increase in the air velocities cause the bed to bubble, which gives rise to the term fluidised. There are two types of fluidised-bed technologies, viz.,

- bubbling bed and
- circulating bed.

The differences are reflected in the relationship between air flow and bed material, and have implications for the type of wastes that can be burned, as well as the heat transfer to the energy recovery system.

Unlike mass-burn incinerators, fluidised-bed incinerators require front-end preprocessing, also called fuel preparation. They are generally associated with source separation because glass and metals do not fare well in these systems and also they can successfully burn wastes of widely varying moisture and heat content, so that the inclusion of paper and wood, which are both recyclable and burnable, is not a crucial factor in their operation.

Fluidised-bed systems are more consistent in their operation than mass burn and can be controlled more effectively to achieve higher energy conversion efficiency, less residual ash and lower air emissions. In general, however, these systems appear to operate efficiently on smaller scales than mass-burn incinerators, which may make them attractive in some situations. For this reason, fluidized-bed technology may be a sound choice for high-recycling cities in developing countries when they first adopt incineration.



Fluidized-bed incinerator

PARTS OF AN INCINERATOR

Same as chemical volume reduction

INCINERATOR EFFLUENT GAS

The operation of the combustion process plays an important role in the formation of pollutants, which are carbon monoxide, NOx (oxides of nitrogen), hydrocarbons and other volatile organic compounds. It also produces gaseous stream containing dust, acid gases (HCl, SOx, HF), heavy metals and traces of dioxins. The majority of modern incinerators, however, produce less particulate and gaseous pollutants than their predecessors. Also, emissions from incinerators are controlled by a combination of measures that use both the pollution prevention approach and various control equipment.

The various gaseous pollutants formed due to incineration processes are:

Carbon dioxide (CO_2): This is one of the main products of incineration, and the other main product is water. At low concentrations, CO_2 has no short-term toxic or irritating effect, as it is abundant in the atmosphere and necessary for plant life and is not generally considered a pollutant. Nevertheless, due to the high increase in global concentration of CO_2, it has been recognised as one of the gases responsible for global warming.

Carbon monoxide (CO): An incomplete combustion of carbon due to the lack of oxygen forms CO. This gas is toxic, as it reacts with the haemoglobin in the blood, causing a decrease of available oxygen to the organisms. This lack of oxygen produces headache, nausea, suffocation and eventually death. Carbon monoxide in the flue gas is used to monitor the incomplete combustion of the other emissions, such as un-burnt hydrocarbons and provide information on the performance of the incinerator.

Sulphur oxides (SO_x): The emission of SO_x is a direct result of the oxidation of sulphur present in solid waste, but other conditions such as the type of incinerator used and its operating conditions also influence its production. Approximately 90% of SO_x emissions are SO_2 and 10% are SO_3. In the atmosphere, most of the SO_2 is transformed into SO_3, which leads to the production of H_2SO_3 (sulphurous acid) and H_2SO_4 (sulphuric acid), increasing the acidity of rain. At high concentrations, it causes eye, nose and throat irritation, and other respiratory problems.

Nitrogen oxides (NO_x): This is predominantly formed during the incineration process. However, they oxidise to NO_2 in the atmosphere. NO_x is formed from two main sources – thermal NO_x and fuel NO_x. In thermal formation, the oxygen and nitrogen react in the air. Fuel NO_x is formed during the reactions between oxygen and nitrogen in the fuel. Nitrogen oxides are important, as they participate in several processes in atmospheric chemistry. They are precursors of the formation of ozone (O_3) and preoxy acetal nitrate (PAN). These photochemical oxidants are responsible for smog formation and cause acid rain.

Particulates: This is formed during the combustion process by several mechanisms. The turbulence in the combustion chambers may carry some ash into the exhaust flow. Other inorganic materials present in the waste volatilise at combustion temperature and later condense downstream to form particles or deposits on ash particles. The main component of fly ash is chemically inert silica; but it may also contain toxic metal and organic substances.

Hydrochloric acid (HCl): Hydrochloric acid results from the high concentration of chlorine containing materials (e.g., some type of plastics like polyvinyl chloride) in solid waste. Chlorine easily dissolves in water to form HCl. Its presence in the gaseous state may increase the acidity of local rain and ground water, which can damage exposed and unprotected metal surfaces, erode buildings and may affect the mobilisation of heavy metals in soil.

Hydrogen fluoride (HF): Hydrogen fluoride is more toxic and corrosive than HCl, although its presence in the emissions from solid waste incinerators occurs in much smaller quantities. It is formed due to the presence of trace amounts of fluorine in the waste.

Heavy metals (Hg, Cd, Pb, Zn, Cu, Ni, Cr): Solid waste contains heavy metals and metallic compounds in the combustible and incombustible fractions. During the incineration process, metals may vaporise directly or form oxides or chlorides at high temperatures in the combustion zone. They condensate over other particles and leave the incineration process in the flue gas.

Dioxins and furans: Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) have been detected in the emissions from solid waste incinerators. Dioxins can be formed in all combustion processes, where organic carbon, oxygen and chlorine are present, although the processes by which they are formed during incineration are not completely understood. The concern over dioxins and furans has increased after a number of animal studies have shown that for some species, they are carcinogenic and highly toxic, even at very low levels of exposure.