Internal Assesment Test – II

SOLID WASTE MANAGEMENT (15CV651)

SOLUTION

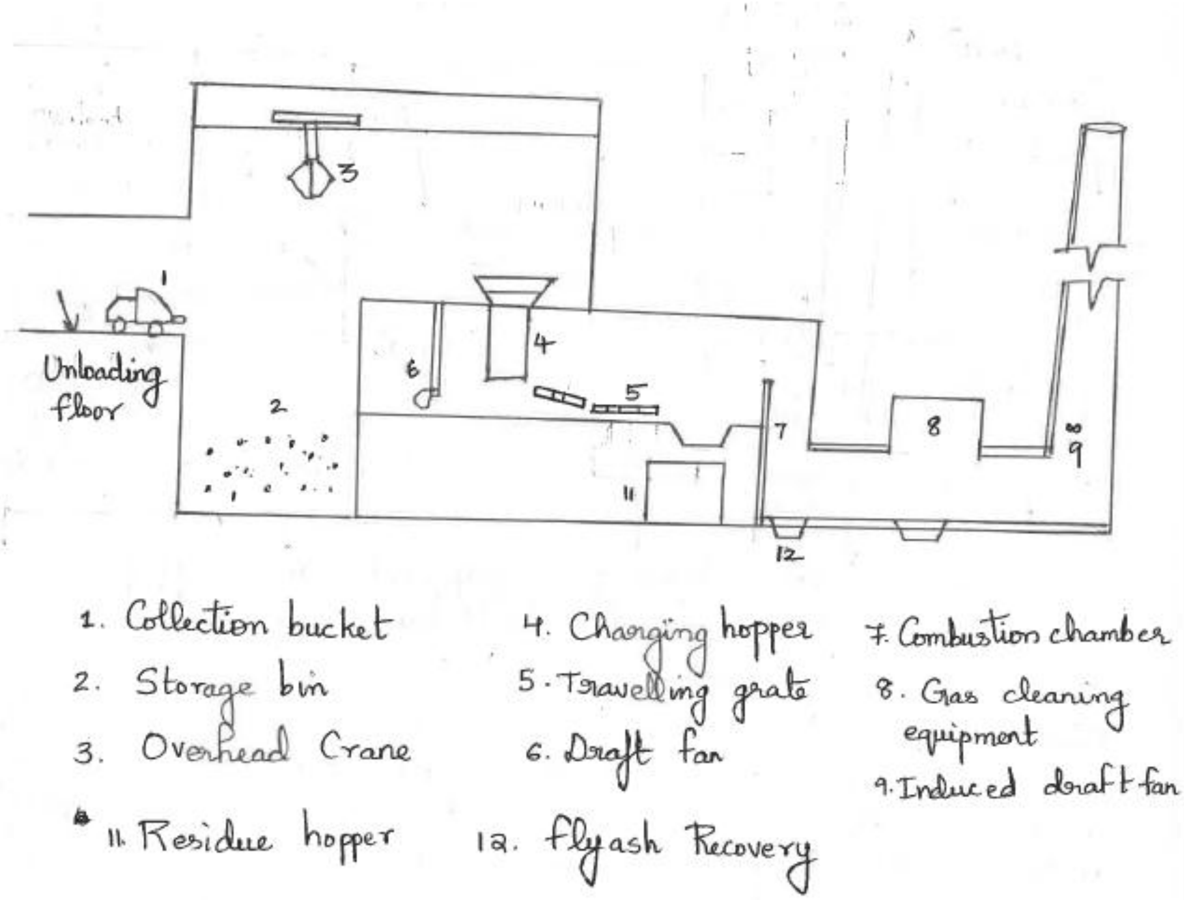
1. Incineration can be defined as a controlled combustion process for burning of solid, liquid and gaseous combustible waste to gases and residue containing non combustible materials. Burning of refuse at high temperatures in furnaces are called Incinerators. Incineration is a chemical process used to reduce the volume of solid wastes. The process can also be called as chemical volume reduction. Chemical process such as pyrolysis, hydrolysis and chemical conversion are also effective in reducing the volume of wastes. Incineration process is preferred over other process because it can be used both for volume reduction and for power production. Normally only the combustible matter such as garbage, rubbish and dead animals are burnt and the incombustible matter like broken glass, china ware, metals etc are either left unburnt or are separated for recycling and reuse before burning the solid wastes. The incinerators along with the non- recycled incombustible materials may, however, measure as much as 10-25% of the original waste, which in any case has to be disposed either by sanitary land filling or in some other productive manner. For example the clinkers can be used as aggregates for making low grade concrete or as road material and the ashes can be used for making bricks. The heat produced during burning of the refuse is used in the form of steam power for running turbines to generate electricity.

Incineration of Municipal wastes:

The most attractive feature of the incineration process is that it can be used to reduce the original volume of combustible solid wastes by 80 to 90%. In some of the newer incinerators designed to operate at temperatures high enough to produce a molten material before cooling it may be possible to reduce the volume to about 5% or less. Although technology of incineration has advanced in the past two decades, air pollution control remains a major problem in implementation. In addition to the use of large municipal incinerators, on site incineration is also used at individual residences apartments, stores, industries, hospitals and other institutions.

Section through a typical municipal incinerator

The basic operations involved in the incineration of solid wastes are identified in the figure. The operation begins with the unloading of solid wastes from collection trucks into a storage bin. The length of the unloading platform and storage bin is a function of the number of trucks that must unload simultaneously. The over head crane is used to batch load waste into the charging hopper. The crane operators can select the mix of waste to achieve a fairly even moisture content. Large or incombustible items are also removed from the wastes. Solid wastes from the charging hopper fall into the stokers where they are mass fired. Several different types of mechanical stokers are commonly used. Air may be introduced from the bottom of the grates (under fire air) by means of a forced draft fan or above the grates (over-fire air) to control burning rates and furnace temperature. The hottest part of the fire is above the burning grate various gases are driven off in the combustion process taking place in the furnace, where the temperature is about 1400^0F. These gases and small organic particles pass into a secondary chamber commonly called a “combustion chamber” and burnt at temperatures above 1600^{0}F. To meet local air pollution control regulations space must be provided for air cleaning equipment as well as to supply air to the incinerator itself, an induced draft fan may be needed. The end products of incineration are the cleaned gases that are discharged to the stack. Ashes and unburnt materials from the grates fall into a residue hopper located below the grates where they are quenched with water. Fly ash which settles in the combustion chamber is removed by means of a fly ash sluice way. Residue from the storage hopper may be taken to a sanitary landfill.



2. **Sanitary landfill methods**

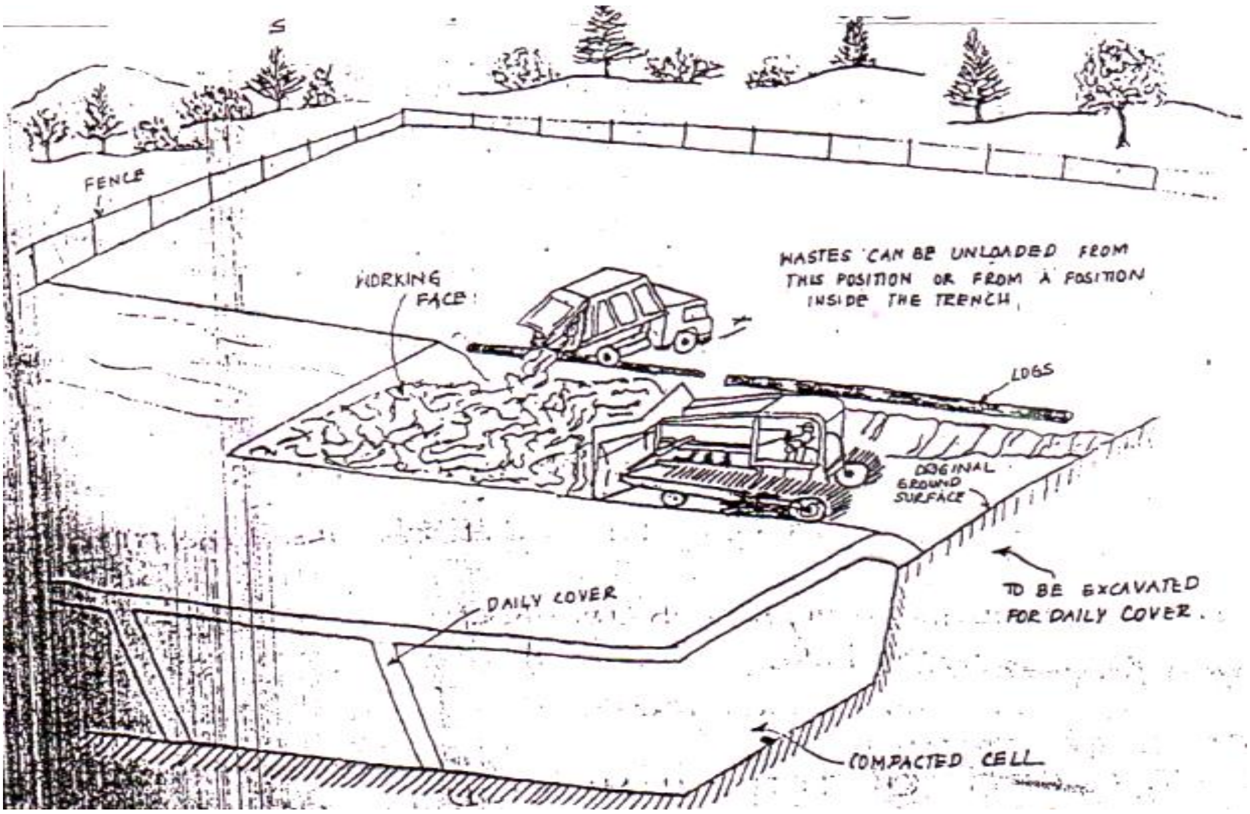
The principle methods used for the land filling of MSW are

i) Excavated cell/trench method.
ii) Area method (Ramp method)
iii) Canyon/ depression method

Excavated cell or trench method

The excavated cell/trench method of land filling is ideally suited for areas where an adequate depth of cover material is available at the site and here the water table is not near the surface. Typically MSW are placed in cell or trenches excavated in the soil. The soil excavated from the site is used for daily and final cover. The excavated cells/trenches are usually lined with synthetic membrane liners or low permeability clay or a combination of the two to limit the movement of landfill gases and leachate. Excavated cell are typically square, upto 1000ft in width and length with side slopes of 1.5:1 to 2:1 in length, 3-10ft in depth and 15-50ft in width.

Landfills are allowed to be construct below the high ground, water level if special provisions are made to prevent ground water from from entering the landfill and to contain or eliminate the movement of leachate or gases from completed cells. Usually the site is dewatered, excavated and then lined in compliance with local regulation. The dewatering facilities are operated until the site is dewatered, excavated and then lined in compliance with local regulation. The dewatering facilities are operated until the site is filled to avoid the creation of uplift pressures that could cause the liner to heave and rupture.



Area method (Ramp method)

Is used when the terrain is unsuitable for the excavation of cells or trenches in which to place the Solid waste. In high ground water conditions necessitate the use of area method. Landfill site preparation include the installation of liner and leachate control system, cover material must be hauled in by truck and earth moving equipment from adjacent land or from borrow pit areas. In locations with limited availability of materials that can be used as cover, compost produced from yard waste and MSW has been used successfully as intermediate cover material. Other techniques that have been used include the use of movable temporary cover material such as soil and geo membranes. Soil and Geo-membranes placed temporarily over a complete cell be removed before the next lift is began.

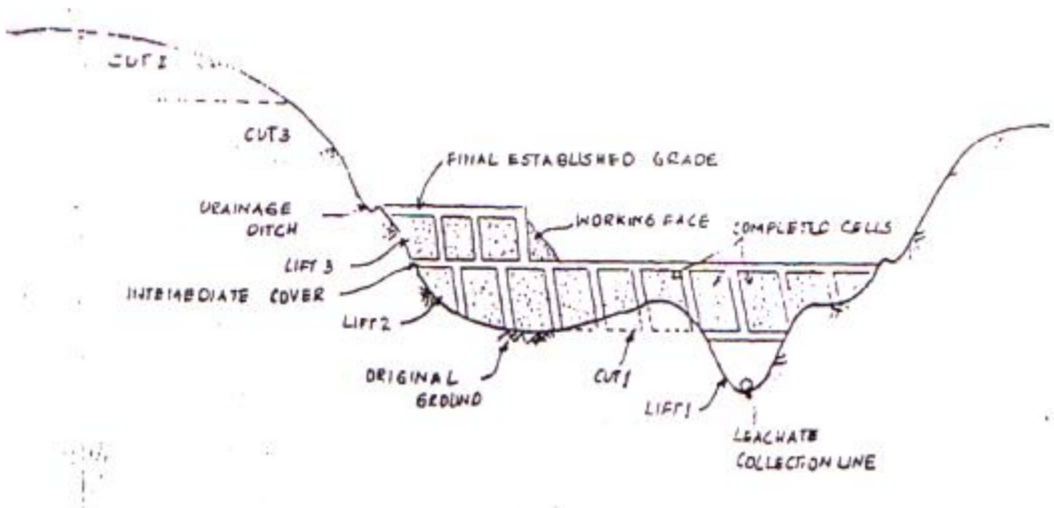
Canyons or Ravines: Dry Borrow pits and Quarries have been used successfully as landfills. The Techniques to place and compact solid waste in canyons or depression landfills vary with.

i) Geometry of site.

ii) Characteristics of available cover material.
iii) Hydrology and Geology of site.
iv) Type of leachate and gas control facilities to be used.
v) Access to the site.

In a Canyon site filling starts at the head (higher) end of the canyon and ends at the mouth. This practice prevents accumulation of water behind landfill. Waste usually are deposited on the canyon floor and from there are pushed against the canyon face at a slope of 2:1. In this way a high degree of compaction can be achieved.

Control of surface drainage often is a critical factor. A key to the successful use of this method is the availability of adequate material to covert the individual lift as they are completed and to provide the entire landfill when the final height is raised. Cover material is excavated from the canyon walls or floor and abandoned quarries may not contain sufficient soil for intermediate cover so that cover material may have to be imported. Compost produced from yard waste and MSW can also be used for intermediate cover layers.



3. Pyrolysis is the thermal processing of waste in the complete absence of oxygen. Both pyrolysis and gasification systems are used to convert solid waste into gaseous, liquid and solid fractions. The principal difference between the two systems is that pyrolysis systems use an external source of heat to drive the endothermic pyrolysis reactions in an oxygen free environment, where as gasification systems are self sustaining and use air or oxygen for the partial combustion of solid waste.

Description of the pyrolysis process: Because most organic substances are thermally unstable, they can, upon heating in an oxygen free atmosphere, be split through a combination of thermal cracking and condensation reactions into gaseous, liquid and solid fractions. Pyrolysis is the term used to describe the process. In contrast to the combustion and gasification processes, which are highly exothermic, the pyrolytic process is highly endothermic, requiring an external heat source. For this reason, the term destructive distillation is often used as an alternative term for pyrolysis.

The three major component fractions resulting from the pyrolysis process are the following

1. A gas stream, containing primarily hydrogen, methane, carbon monoxide, carbon dioxide and various other gases, depending on the organic characteristics of the material being pyrolyzed.

2. A liquid fraction, consisting of a tar or oil stream containing acetic acid, acetone, methanol and complex oxygenated hydrocarbons. With additional processing the liquid fraction can be used as a synthetic fuel oil as a substitute for conventional No.6 fuel oil.
3. A char, consisting of almost pure carbon plus any inert material originally present in the solid waste.

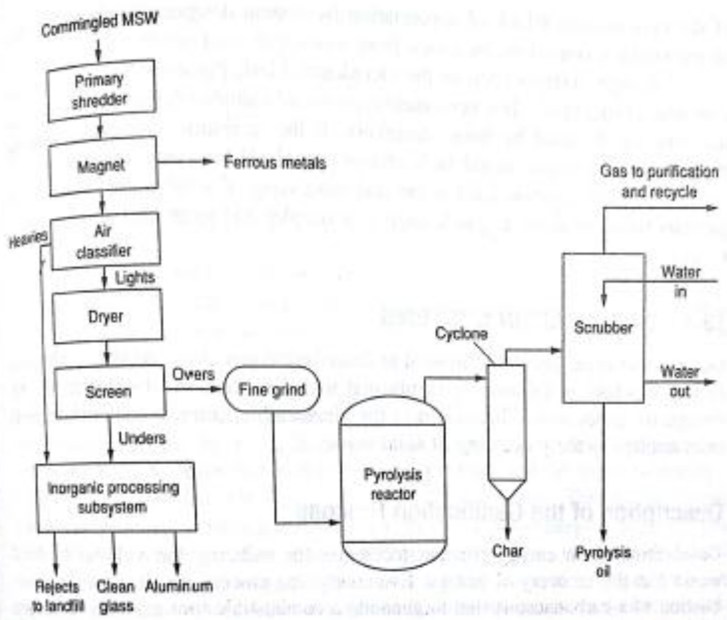


FIGURE 13-9
Schematic diagram of the Occidental flash pyrolysis system for the organic portion of MSW [30].

4. Different types of incinerators:

a.Fixed grate: The older and simpler kind of incinerator was a brick-lined cell with a fixed metal grate over a lower ash pit, with one opening in the top or side for loading and another opening in the side for removing incombustible solids called clinkers.

b.Rotary-kiln: The rotary-kiln incinerator is used by municipalities and by large industrial plants. This design of incinerator has 2 chambers: a primary chamber and secondary chamber. The primary chamber in a rotary kiln incinerator consists of an inclined refractory lined cylindrical tube. The inner refractory lining serves as sacrificial layer to protect the kiln structure. This refractory layer needs to be replaced from time to time. Movement of the cylinder on its axis facilitates movement of waste. In the primary chamber, there is conversion of solid fraction to gases, through volatilization, destructive distillation and partial combustion reactions. The secondary chamber is necessary to complete gas phase combustion reactions.

c.Fluidized bed: A strong airflow is forced through a sandbed. The air seeps through the sand until a point is reached where the sand particles separate to let the air through and mixing and churning occurs, thus a fluidized bed is created and fuel and waste can now be introduced. The sand with the pre-treated waste and/or fuel is kept suspended on pumped air currents and takes on a fluid-like character. The bed is thereby violently mixed and agitated keeping small inert particles and air in a fluid-like state. This allows all of the mass of waste, fuel and sand to be fully circulated through the furnace.

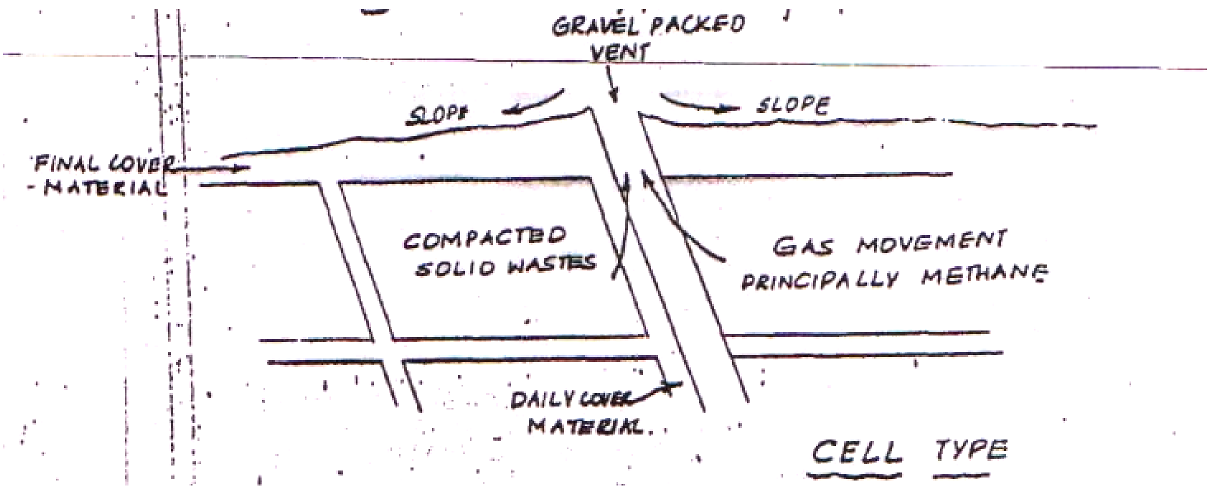
d.Moving grate: The waste is introduced by a waste crane through the "throat" at one end of the grate, from where it moves down over the descending grate to the ash pit in the other end.

5. **Control of gas movement**

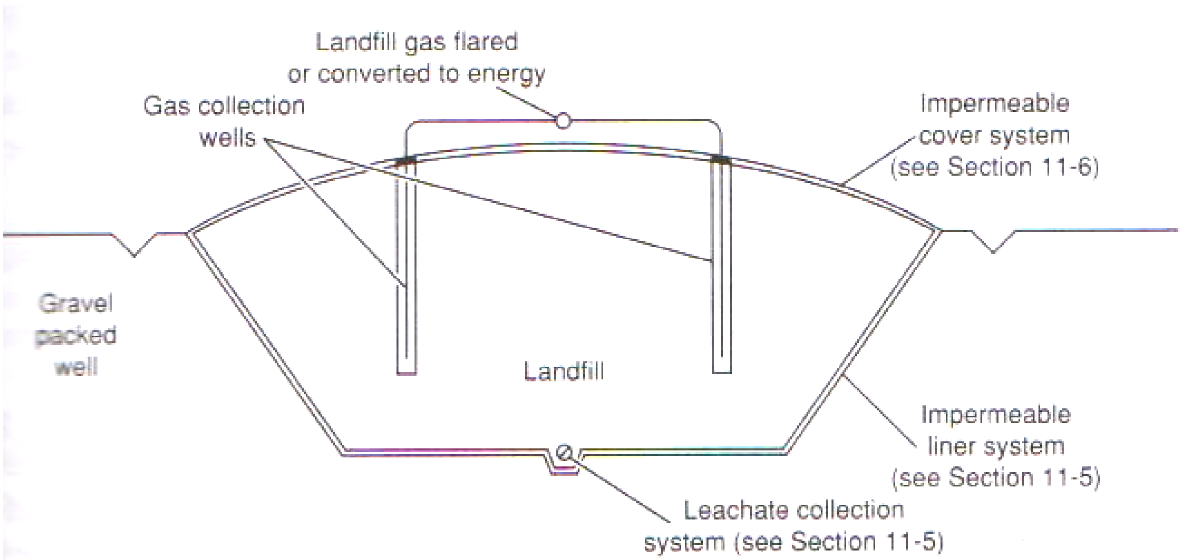
The movement of gases in landfills can be controlled by constructing vents and barriers and by gas recovery.

Control of gas movement with vents and barriers

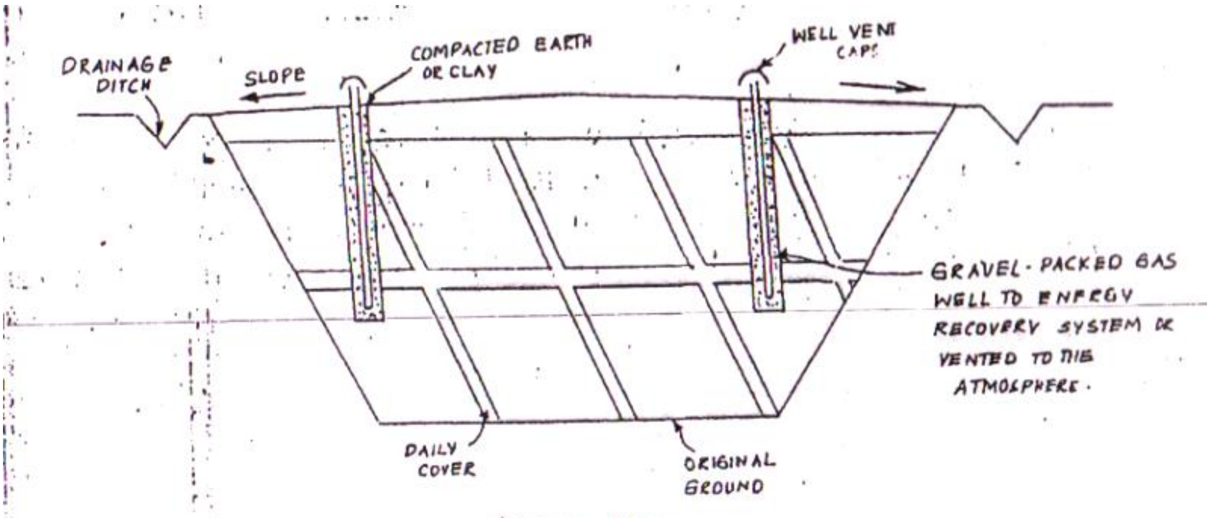
The lateral movements of gases produced in a landfill can be controlled by installing vents made of materials that are more permeable than the surrounding soil.



Gas vents are constructed of gravel. Barrier or well vents also can be used to control the lateral movement of gases. Well vents are often used in conjunction with lateral surface vents buried below grade in a gravel trench. Control of the downwards movement of gases can be accomplished by installing perforated pipes in a gravel layer at the bottom of the landfill. If the gases cannot be vented laterally, it may be necessary to install gas wells and to vent the pumped gas to the atmosphere.



Use of impermeable lines for land fill



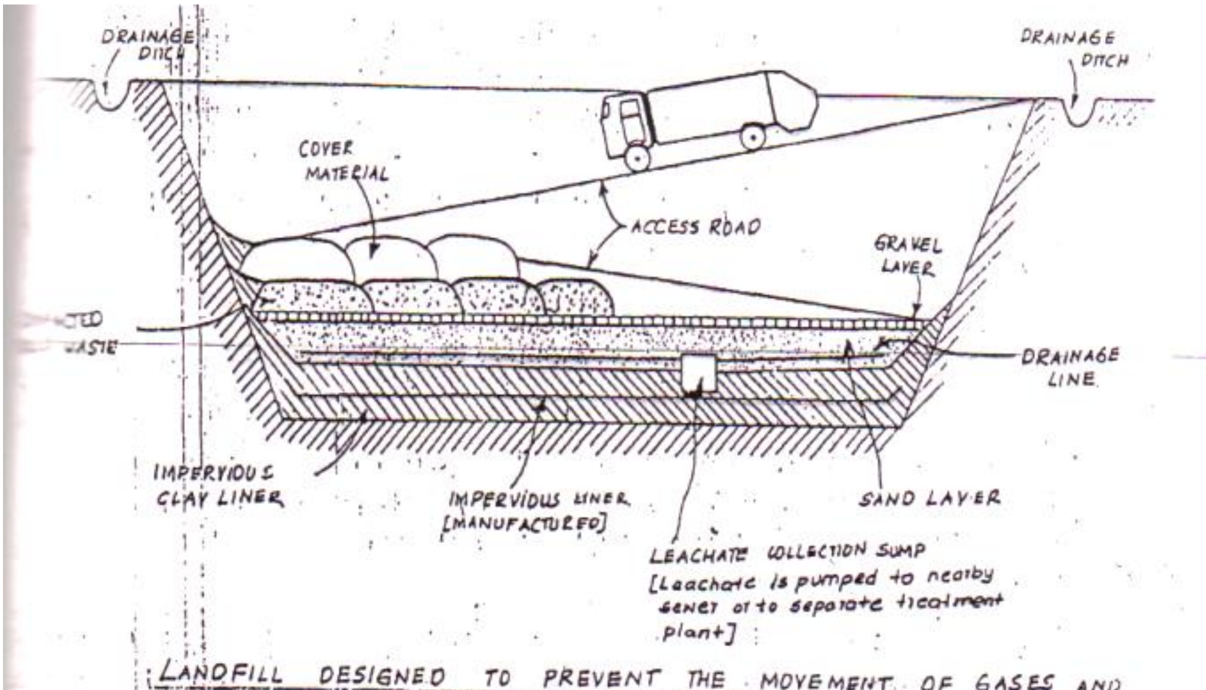
WELL TYPE

The movement of landfill gases through adjacent soil formations can be controlled by constructing barriers of materials that are more impermeable than the soil. Some of the landfill sealants that are available for this use are Betonites, illites, Kaolinites, sodium carbonate, silicates, pyrophosphate, polymers, rubber latex etc. out of these, the compacted clay is most common.

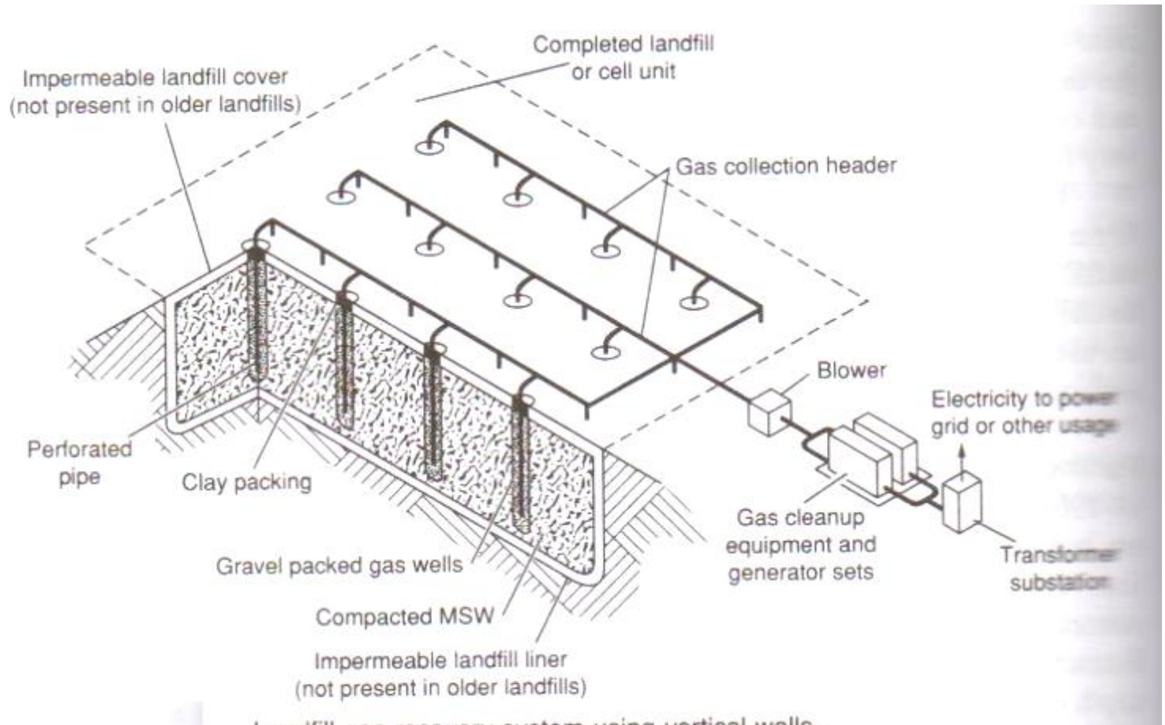
Control of gas movement by recovery:

The movement of gases in landfills can also be controlled by installing gas recovery wells in complete landfill. Clay and other liners are used where landfill gas is to be recovered. In some gas recovery systems, leachate is collected and recycled to the top of the landfill and reinjected through perforated lines located in drainage trenches. Typically the rate of gas production is greater in leachate recirculation systems or where water is added.

Although gas-recovery system have been installed in some large municipal landfills, the economics of such operations are at present, not well defined. The cost of the gas, clean up and processing equipment may limit the recovery of land fill gases especially from small landfills.



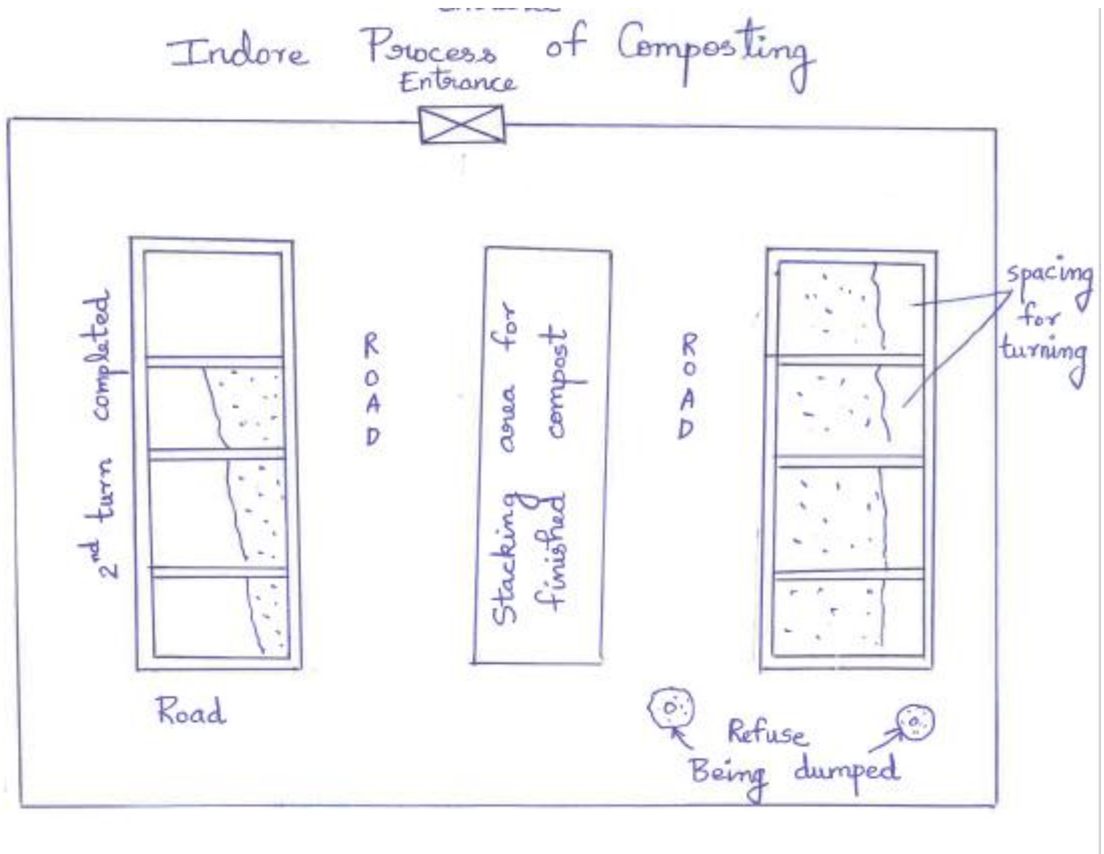
LANDFILL DESIGNED TO PREVENT THE MOVEMENT OF GASES AND LEACHATE



Landfill gas recovery system using vertical wells.

6. Indore process and Bangalore process of composting of Muncipal Solid Waste

Indore process of composting of Muncipal Solid Waste:Uses manual turning of piled up mass (refuse+night soil), for its decomposition under aerobic conditions. In this method, layers of vegetable wastes and night soil are alternatively piled in depths of about 7.5 to 10cm each, to a total depth of about 1.5m in a trench, or above the ground to form a mound called a windrow. A windrow is a long mound or stack of MSW (mixed with cattle dung and human excreta if needing disposal) dumped on land in a height of about 1.5m to 2m, usually about 2.5m to 3m wide at the base. Most windrows are conical in crossection and about 50m in length. The composting waste is aerated by periodically turning the waste mix in the windrow, or in the trench, as the case may be. The manual turning with a pitchfork can be adopted at smaller instillations, while at larger plants, mechanical devices like self-propelled overcab loaders, rotary ploughs etc may be used to turn the refuse once or twice per week, which serves to introduce oxygen and to control the temperature. The moisture content of the turning mass is maintained at about 55% for getting optimum decomposition of the waste mass. This process of turning is continued for about 4 to 5 weeks, during which time biodegadable organics are consumed. The waste component mass is finally allowed to cure for another 2 to 8 weeks without any turning. The entire composting process thus takes about 3-4 months time to complete, after which compost becomes ready for being taken out for use or for sale.



Bangalore process of composting of Muncipal Solid Waste: Anaerobic decomposition of wastes and doesnot involve any turning or handling of the mass and hence cleaner than Indore method. The refuse and night soil, in this method are piled up in layers in an underground earthern trench (about 10m*1.5m*1.5m). This mass is covered at its top by layer of earth of about 15cm depth, and is finally left over for decomposition. Within 2 to 3 days of burial, intensive bioloigical action starts taking place and organic matter begins to be destroyed. Considerable heat gets evolved in the process, which raises the temperature of the decomposing mass to about 75°C. The heat prevents the breading of flies by destroying the larvae. After 4 to 5 months (depending upon the season), the refuse gets fully stabilised and changes into a brown coloured odourless innocuous powdery dry mass, called humus. This humus is removed from the trenches, sieved on 12.5mm sieves to remove stones, broken glass, brick bats, etc and then sold out in the market as manure. The empty trenches can again be used for receiving further batches of refuse. The initial C-N ratio and moisture content of the compost heap are the two important controlling factors in the success of anaerobic digestion, which finally produces a compost free from pathogens and contains 1% N, 1.1% P(as P_2O_5)and 1.5% K(as K_2O) on dry basis, thus proving to be a valuable nutrient for the soils, along with producing biogas as a by-product.