Solid waste treatment: Incineration & Landfill

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Solid Waste

- Waste is defined as an unusable or unwanted substance or material.
- It can be in solid, liquid or gaseous form.
- Solid waste is a term usually used to describe non-liquid materials arising from domestic, trade, commercial, agricultural and industrial activities, and from public services.
- The components that constitute the solid waste are paper, textile, lather, food waste, yard waste, rubber, metals, plastic and glass.
- Certain types of wastes that cause immediate danger to exposed individuals or environments are classified as hazardous.
- All nonhazardous solid waste from a community that requires collection and transport to a processing or disposal site is called refuse or municipal solid waste (MSW).
- Refuse includes garbage and rubbish. Garbage is mostly decomposable food waste; rubbish is mostly dry material such as glass, paper, cloth, or wood.
- Garbage is highly putrescible or decomposable, whereas rubbish is not.
- Trash is rubbish that includes bulky items such as old refrigerators, couches, or large tree stumps. Trash requires special collection and handling.

Methods of Solid Waste Disposal and Management

Solid Waste Open Burning: is not the perfect method in the present scenario.

Sea dumping process: can be carried out only in coastal cities. This is very costly procedure and not environment friendly.

Solid wastes sanitary landfills: is simple, clean and effective.

- A deep trench of 3 to 5 m is excavated and micro-organisms act on the organic matter and degrade them.

Incineration method: is suitable for combustible refuse. High operation costs and construction are involved in this procedure. This method would be suited in crowded cities where sites for land filling are not available.

Composting process: Decomposable organic matter is separated and composted in this procedure.

- Yields are stable end products and good soil conditioners, can be used as a base for fertilizers.

Disposal by Ploughing into the fields: are not commonly used. These disposals are not environment friendly in general.

Disposal by hog feeding: is not general procedure in India. Refuse is ground well in grinders and then fed into sewers.

- Disposal of garbage into sewers – BOD and TSS increases by 20-30%
- Disposal of residual refuse – still a problem

Salvaging procedure: Materials such as metal, paper, glass, rags, certain types of plastic and so on can be salvaged, recycled, and reused.

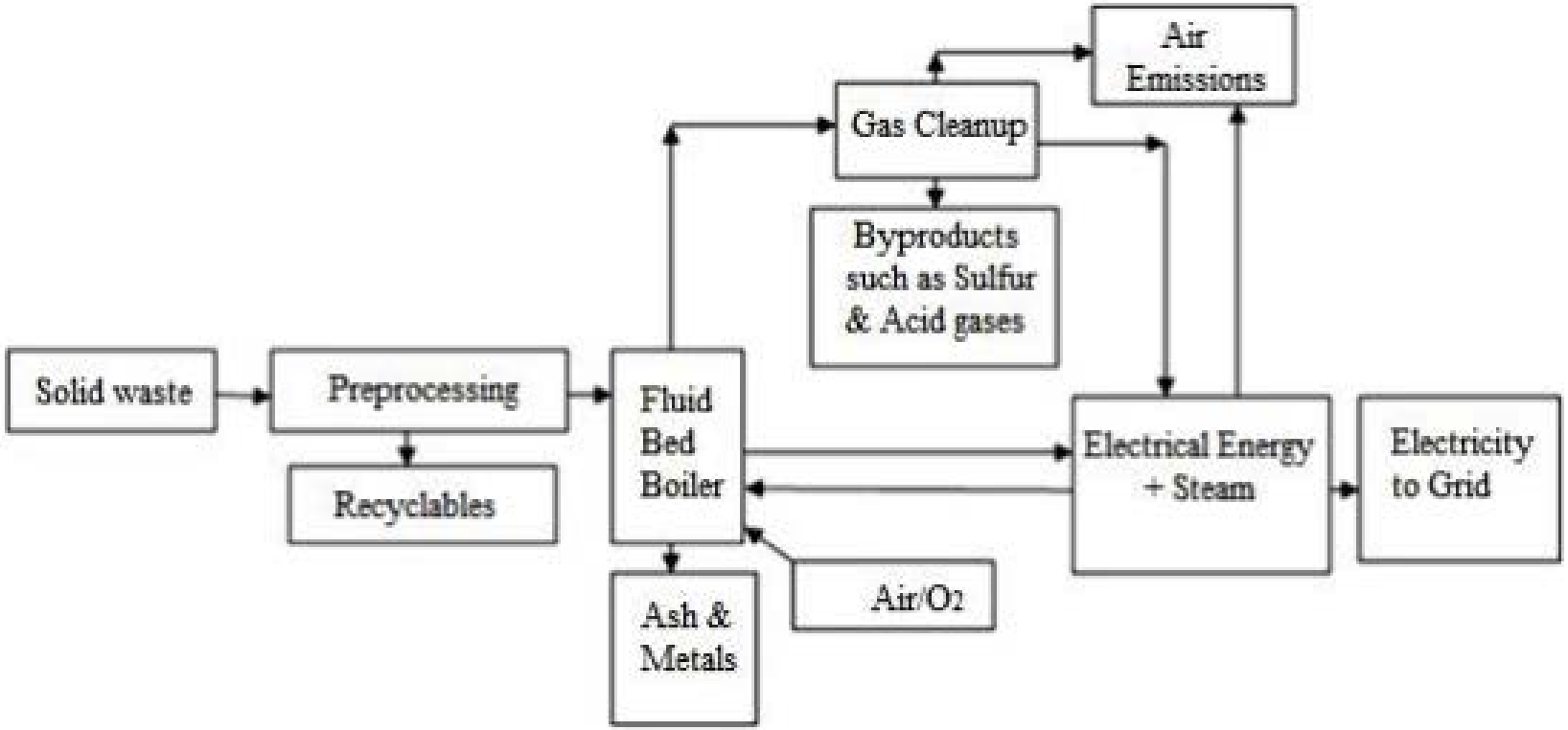
Incineration

- Burning is a very effective method of reducing the volume and weight of solid waste, though it is a source of greenhouse gas emissions.
- In modern incinerators the waste is burned inside a properly designed furnace under very carefully controlled conditions.
- The combustible portion of the waste combines with oxygen, releasing mostly carbon dioxide, water vapour, and heat.
- Incineration can reduce the volume of uncompacted waste by more than 90 %, leaving an inert residue of ash, glass, metal, and other solid materials called bottom ash.
- The gaseous by-products of incomplete combustion, along with finely divided particulate material called fly ash, are carried along in the incinerator airstream.
- In order to remove fly ash and gaseous by-products before they are exhausted into the atmosphere, modern incinerators must be equipped with extensive emission control devices.
- Such devices include fabric baghouse filters, acid gas scrubbers, and electrostatic precipitators.
- Bottom ash and fly ash are usually combined and disposed of in a landfill.
- If the ash is found to contain toxic metals, it must be managed as a hazardous waste.

Modern incinerators

- Modern incinerators are usually built with a rectangular furnace, although rotary kiln furnaces and vertical circular furnaces are available.
- Furnaces are constructed of refractory bricks that can withstand the high combustion temperatures.
- Combustion in a furnace occurs in two stages: primary and secondary.
- In primary combustion, moisture is driven off, and the waste is ignited and volatilized.
- In secondary combustion, the remaining unburned gases and particulates are oxidized, eliminating odours and reducing the amount of fly ash in the exhaust.
- When the refuse is very moist, auxiliary gas or fuel oil is sometimes burned to start the primary combustion.

A schematic diagram of incineration process



Waste-to-energy incinerators

- The energy value of refuse can be as much as one-third that of coal, depending on the paper content, and the heat given off during incineration can be recovered by the use of a refractory-lined furnace coupled to a boiler.
- Boilers convert the heat of combustion into steam or hot water, thus allowing the energy content of the refuse to be recycled.
- Incinerators that recycle heat energy in this way are called **waste-to-energy plants**.
- Instead of a separate furnace and boiler, a water-tube wall furnace may also be used for energy recovery.
- Such a furnace is lined with vertical steel tubes spaced closely enough to form continuous sections of wall.
- The walls are insulated on the outside in order to reduce heat loss.
- Water circulating through the tubes absorbs heat to produce steam, and it also helps to control combustion temperatures without the need for excessive air, thus lowering air pollution control costs.
- If a turbine is installed at the plant, both steam and electricity can be produced in a process called **cogeneration**.

Pros and cons of incineration method

- Waste-to-energy systems are more expensive to build and operate than plain incinerators because of the need for special equipment and controls, highly skilled technical personnel, and auxiliary fuel systems.
- On the other hand, the sale of generated steam or electricity offsets much of the extra cost.
- About 80 percent of municipal refuse incinerators in the United States are waste-to-energy facilities.

Landfill

- The basic element of a sanitary landfill is the refuse cell.
- This is a confined portion of the site in which refuse is spread and compacted in thin layers.
- Several layers may be compacted on top of one another to a maximum depth of about 3 metres (10 feet).
- The compacted refuse occupies about one-quarter of its original loose volume.
- At the end of each day's operation, the refuse is covered with a layer of soil to eliminate windblown litter, odours, and insect or rodent problems.
- One refuse cell thus contains the daily volume of compacted refuse and soil cover.
- Several adjacent refuse cells make up a lift, and eventually a landfill may comprise several lifts stacked one on top of the other.
- The final cap for a completed landfill may also be covered with a layer of topsoil that can support vegetative growth.
- Various types of heavy machinery, such as crawler tractors or rubber-tired dozers, are used to spread and compact the refuse and soil.
- Heavy steel-wheeled compactors may also be employed to achieve high-density compaction of the refuse.

Decomposition refuse

- Complete decomposition usually takes more than 20 years.
- Microorganisms act on the organic matter and degrade them.
- Facultative bacteria hydrolyze complex organic matter into simpler water soluble organics.
- These diffuse through the soil where fungi and other bacteria convert them to carbon dioxide and water under aerobic conditions.
- Lower lines of landfill becomes anoxic, where methanogenic bacteria produces methane.
- Aerobic methanotrophic bacteria utilize the methane generated and the rest diffuses into the atmosphere.
- Moisture content – not less than 60% for good biodegradation.
- Temperature in the initial stages of decomposition – as high as 70° C – then drops.
- Reclaimed areas may be used for other uses.

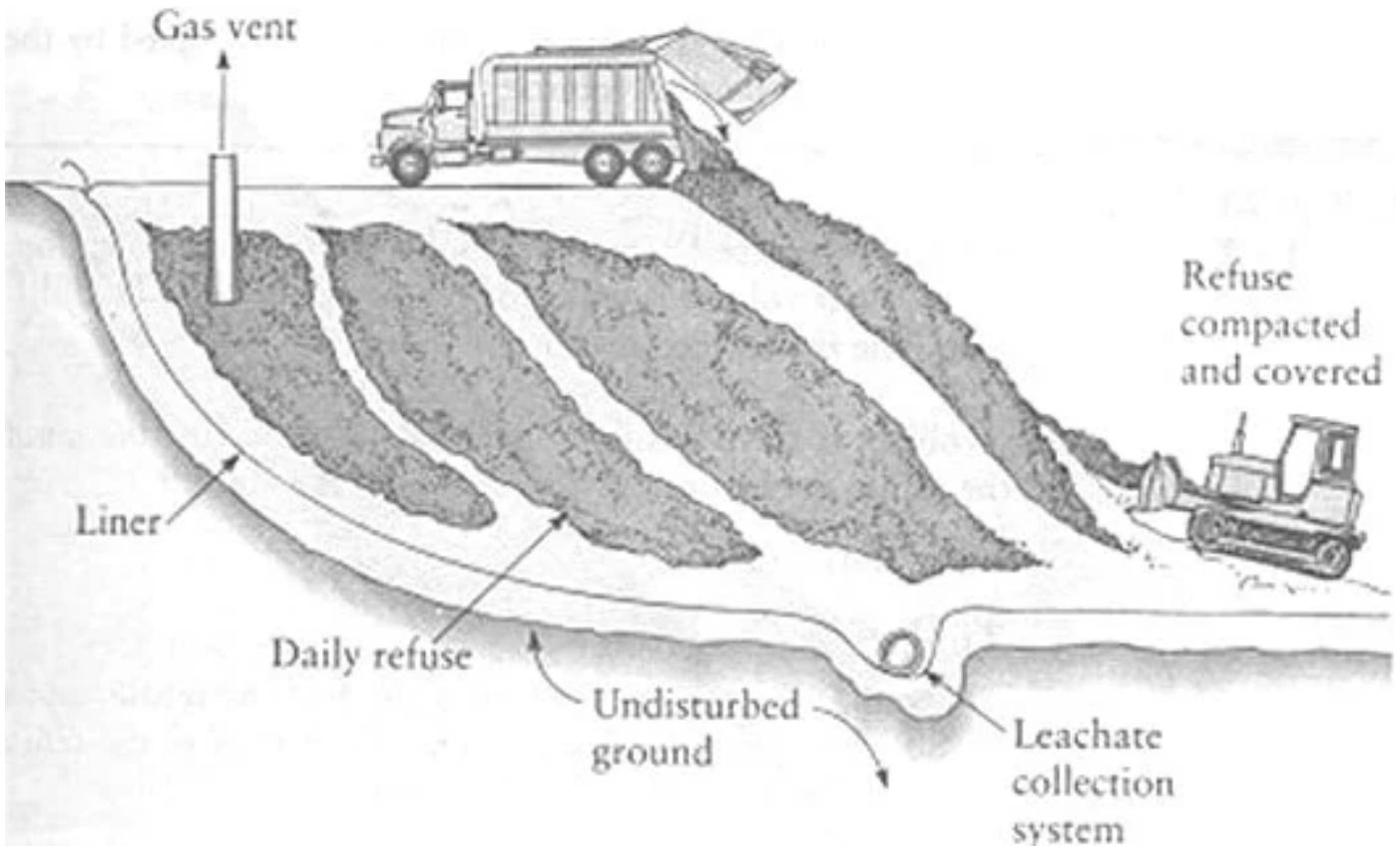
By-products of landfill

- Organic material buried in a landfill decomposes by anaerobic microbial action.
- One of the by-products of this decomposition is methane gas.
- Methane is poisonous and explosive when diluted in the air, and it can flow long distances through porous layers of soil.
- If it is allowed to collect in basements or other confined areas, dangerous fire incidences may arise.
- A highly contaminated liquid called leachate is another by-product of decomposition in sanitary landfills.
- Most leachate is the result of runoff that infiltrates the refuse cells and comes in contact with decomposing garbage.
- If leachate reaches the groundwater or seeps out onto the ground surface, serious environment pollution problems can occur, including the possible contamination of drinking-water supplies.

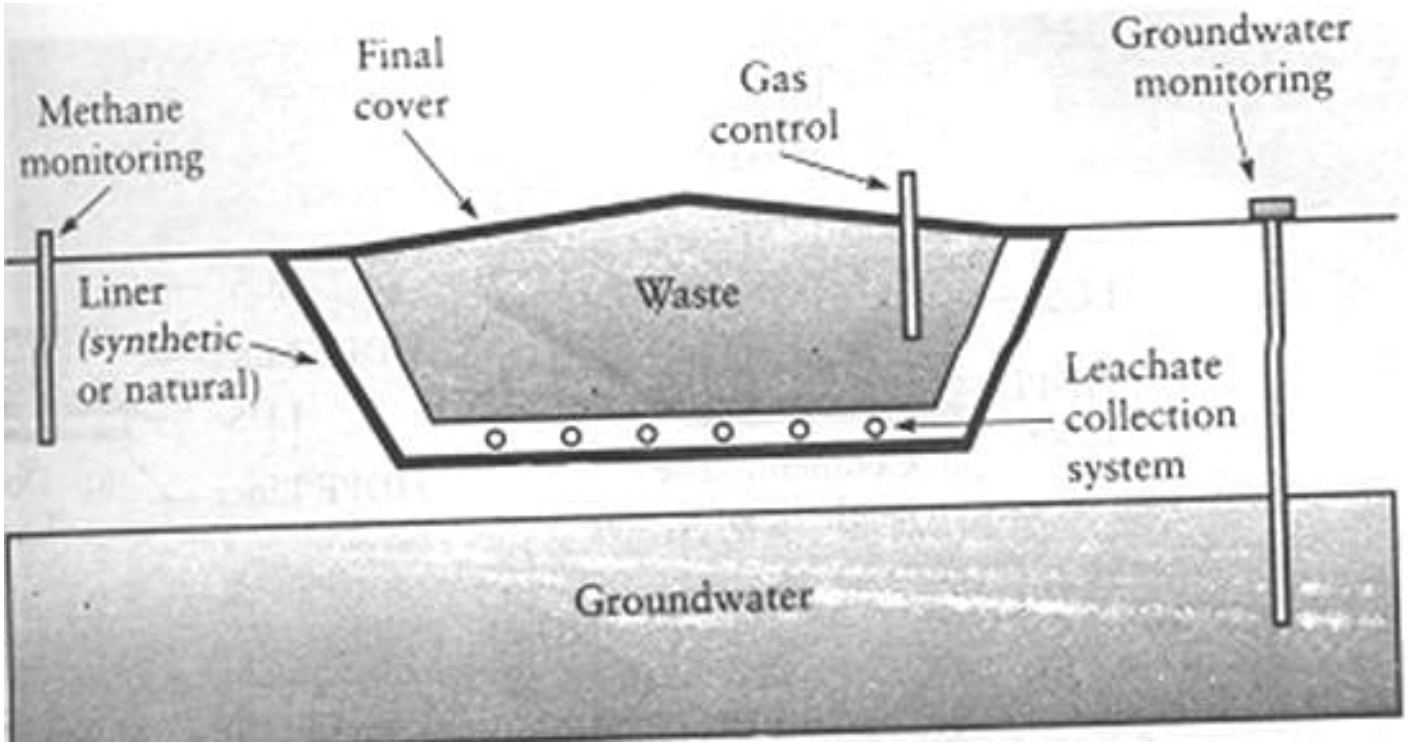
Engineered Landfills of Solid Wastes

- One of the most important factors relating to landfilling is that the buried waste never comes in contact with surface water or ground water.
- Engineering design requirements include a minimum distance between the bottom of the landfill and the seasonally high ground water table.
- Most new landfills are required to have an impermeable liner or barrier at the bottom, as well as a system of groundwater-monitoring wells.
- Completed landfill sections must be capped with an impermeable cover to keep precipitation or surface runoff away from the buried waste.
- Bottom and cap liners may be made of flexible plastic membranes, layers of clay soil, or a combination of both.
- Leachate so collected is treated and then disposed off.
- In modern landfills, methane movement is controlled by impermeable barriers and by gas-venting systems.
- In some landfills the methane gas is collected and recovered for use as a fuel.

A Typical Sanitary Landfill



Components of a Typical Landfill



Typical Constituents of municipal solid waste landfill gas

Component	% by volume (dry)
Methane	45 to 60
Carbon dioxide	40 to 60
Nitrogen	2 to 5
Oxygen	0.1 to 1
Ammonia	0.1 to 1
Hydrogen	0 to 0.2

Pros and Cons of Landfill

- In communities where appropriate sites are available, sanitary landfills usually provide the most economical option for disposal of nonrecyclable refuse.
- However, it is becoming increasingly difficult to find sites that offer adequate capacity, accessibility, and environmental conditions.
- Nevertheless, landfills will always play a key role in solid-waste management.
- It is not possible to recycle all components of solid waste, and there will always be residues from incineration and other treatment processes that will eventually require disposal underground.
- In addition, landfills can actually improve poor-quality land.
- In some communities properly completed landfills are converted into recreational parks, playgrounds, or golf courses.

Questions

- What are solid waste? Write in detail the landfill method of solid waste disposal, associated pros and cons.
- Write short note on:
  - Solid waste & treatment methods
  - Landfill
  - By-products of landfill
  - Incineration