Disposal of Solid Waste

Site Selection and Types of Landfill

Problems associated with open dumping

- **Open dumping** is the **disposal of solid wastes** in a manner **that does not protect the environment** and are exposed to the elements, vectors, and scavengers. They are also susceptible to burning.

- Open dumping **poses huge environmental and health concerns**-

✔ The waste dumped could **catch fire and pollute the atmosphere**. **Methane gas** produced as a result of anaerobic digestion aids in sustaining these fires.

✔ Open dumpsites are **breeding grounds for disease carrying vectors**. It attracts mosquitos, rats and flies.

Burning Kodungaiyur garbage dumpsite, Chennai, India

Problems associated with open dumping (Cont.)

- ✔ Since the wastes in open dumpsites are not properly covered, they are **exposed to natural elements such as wind and rain**.
  - Rain washes off the contaminants and **contaminate the surface water**, **percolate the soil**, and **contaminate the soil and groundwater**.
- ✔ Open dumping **decreases the quality of life** to nearby residents and the local community.

Canal adjacent to Kodungaiyur dumpsite, Chennai

LANDFILL

- Landfills are the **physical facilities used for the disposal of residual solid wastes** in the surface of the earth.
- Landfilling is the process by which residual solid waste is placed in landfill.
- Landfilling includes **monitoring** of the incoming waste stream, **placement and compaction** of waste, and installation of landfill environmental monitoring and **control facilities**.
- Types of landfill:
  - **Sanitary landfill**: engineered facility for the disposal of municipal solid waste
  - **Secured landfill**: for the disposal of hazardous wastes

A secured landfill

Design Life

- Life of a sanitary landfill comprises of an active period and a closure and post-closure period.
- Active period may typically range from **20 to 25 years** depending on the availability of land area.
- Closure and post-closure period, for which a sanitary landfill will be monitored and maintained, will be **15 years** and more after the active period is completed.

Status of MSW management India

Parameter	Status
House-to-house collection of waste	18 states (of 29)
Segregation of waste at the source 5 states	5 states (of 29)
Number of unsanitary landfill sites identified	1,285
Number of sanitary landfill sites constructed	95

***Source**: CPCB, India (2016)*

Types of municipal solid waste (MSW) to be accepted at landfills

- Waste categories suitable for sanitary landfills are the following:

  i. Non-biodegradable and inert waste by nature or through pretreatment.

  ii. Commingled waste (mixed waste) not found suitable for waste processing.

  iii. Pre-processing and post-processing rejects from waste processing sites.

  iv. Non-hazardous waste not being processed or recycled.

- Landfilling of construction and demolition (C&D) waste, where processing options are not available, will be done in a separate landfill or cell where the waste can be stored and mined for future use in earthwork or road projects.

- C&D waste can be used as a daily cover or for road construction at the MSW sanitary landfill.

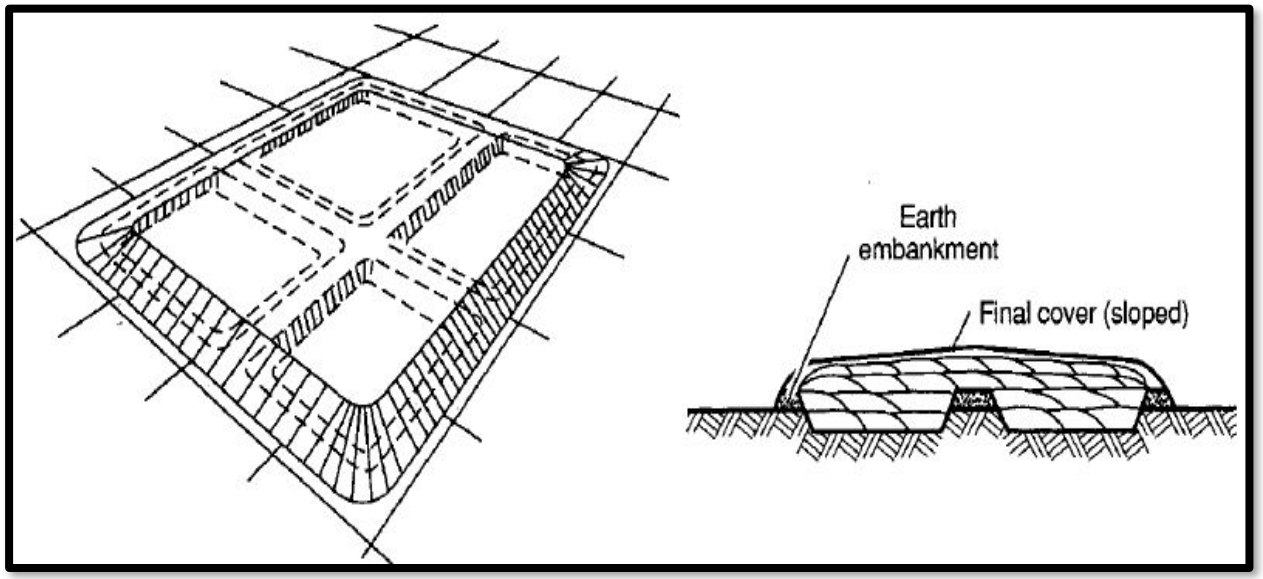
LANDFILLING METHODS

The **principal methods used for the landfilling of MSW** are:

1. Excavated cell/Trench
2. Area
3. Canyon/depression

Excavated/Trench Method

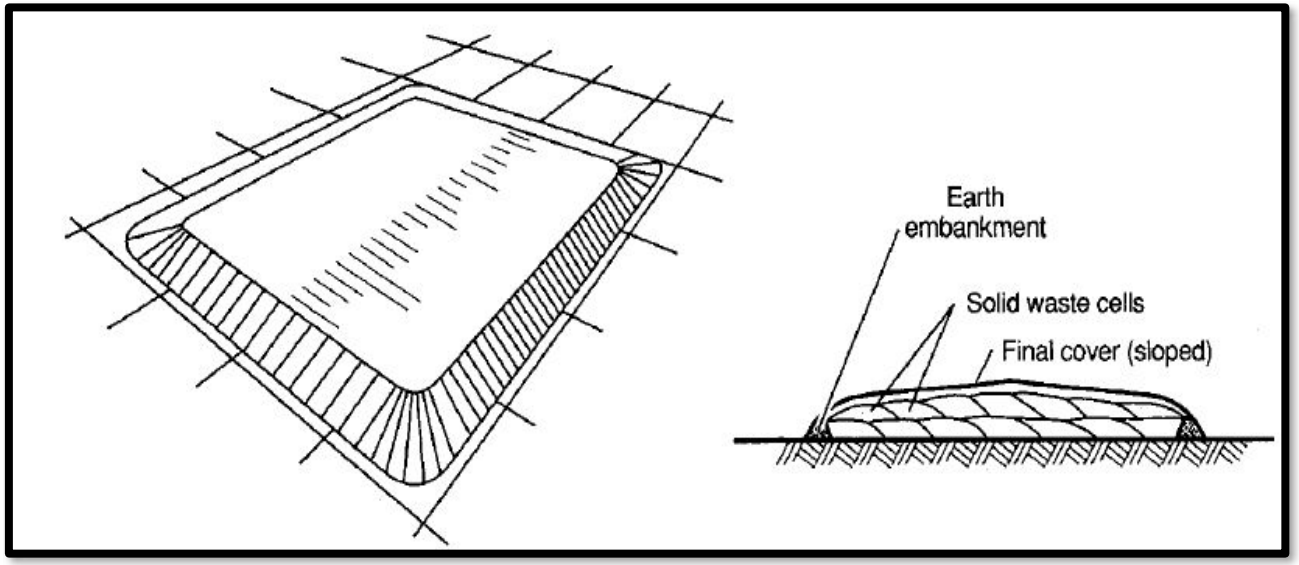
- Used in places where groundwater table is not near surface.
- Trenches are dug and lined with synthetic membrane liners or low-permeable clay or a combination of both.
- The solid wastes are placed in the trenches and the soil excavated from site is used for daily and final cover.
- Trenches are 200-1000 ft. long, 3-10 ft. deep and 15-50 ft. wide



Trench method

Area Method

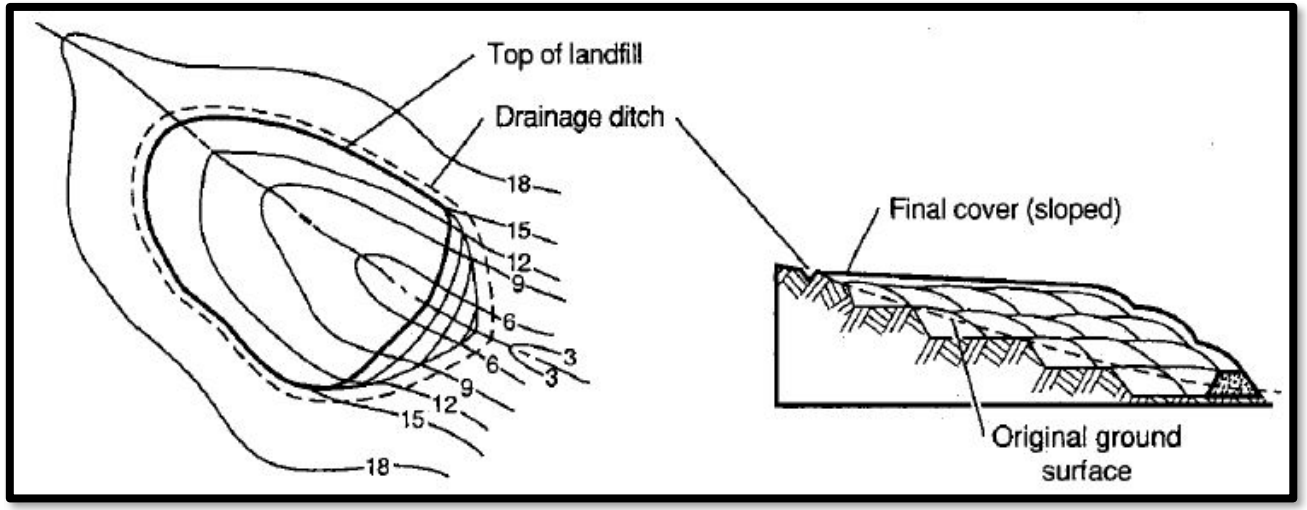
- Used when terrain is unsuitable for excavation such as when the groundwater table is high.
- Cover materials are hauled from different location.
- Site preparation include installation of liner and leachate control system.



Area method

Canyon/Depression Method

- Canyons, ravines, dry borrow pits, and quarries can be used as landfill sites.
- Compacted solidwastes are placed in canyon/depression
- Covermaterials can either be excavatedfrom canyon walls or hauled in from a different location.



Canyon method

LANDFILL SITING CONSIDERATION

1. ***Haul distance***: Close to generation
2. ***Location restrictions***: 20 km away from airport, 200 m away from highways, 500 m from habitation, 300 m from public park, 500 m from water supply well, 200 m from pond, 100 m from rivers
3. ***Available land area*****:** minimum for 20-25 years
4. ***Site access***: should have proper access
5. ***Soil condition and topography***: the soil, if used as cover material, should have low porosity. The topography decides the extend of work required to make the site usable
6. ***Climatology conditions***
7. ***Surface water hydrology***: to establish the existing natural drainage or runoff.
8. ***Geologic and hydrogeologic conditions***: to ensure that the leachate or landfill gas will not impair quality of local groundwater or subsurface or bedrock aquifers
9. ***Local environmental conditions***
10. ***Potential ultimate uses for the complete site***

Source*: Municipal Solid Waste Management Manual, India, 2016*

SITE SELECTION

i. Location criteria

ii. Search area

iii. Development of a list of potential sites

iv. Data collection for potential sites

v. Field visit for local verification and identification of potential sites

vi. Selection of best-ranked sites

vii. Preliminary environmental impact investigation

viii. Final site selection

***Source**: Municipal Solid Waste Management Manual, India, 2016*

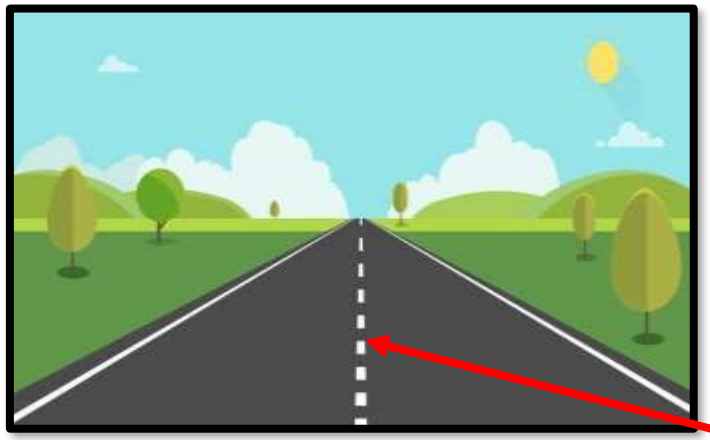
Location criteria

Criteria for identifying suitable land for sanitary landfill sites

Sl No.	Place	Minimum Siting Distance
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas, and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 metres (m) away from the flood plain
3	Pond, lakes, water bodies	200 m
4	Non-meandering water channel(canal, drainage, etc.)	30 m
5	Highway or railway line, water supply wells	500 m from center line
6	Habitation	All landfill facilities: 500 m
7	Earthquake zone	500 m from fault line fracture
8	Flood prone area	Sanitary landfill site not permitted
9	Water table (highest level)	The bottom liner of the landfill should be above 2 m from the highest water table
10	Airport	20km*

* In a special case, a landfill site may be set up within 10–20 km away from the airport or airbase if there is no objection certificate from the civil aviation authority or air force as the case may be.

***Source**: Municipal Solid Waste Management Manual, India, 2016*

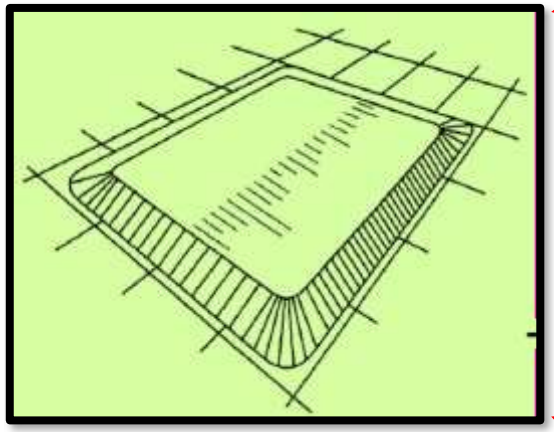


Highways

500m

500m

Human settlement



Landfill

200m

Ponds,lakes or water bodies

20km

Airports

Search Area

- Should ideally be located within the municipal boundary.
- The extent of the search area is usually governed by the economics of waste transportation.

Development of a List of Potential Sites

- After demarcating the search area and considering the various locational criteria, areas having potential for site development should be identified while mapping.
- In areas where land is scarce, degraded sites such as abandoned quarry sites or old waste dumpsites can be considered.

Rough guidance for sanitary landfill sizes

Waste quantity (million tonnes per design life of landfill)	Required site area (ha)
< 1.0	15-20
1.0 – 2.0	20-30
2.0 – 3.0	30-40
> 3.0	>40

***Source**: Municipal Solid Waste Management Manual, India, 2016*

Data collection for potential sites

To exclude unsuitable areas which do not meet specified criteria, the following data are collected:

- Topographic maps
- Soil maps
- Land use plans
- Water use plans
- Flood plain maps
- Geologic maps
- Aerial photographs, satellite imagery, google maps
- Groundwater maps
- Rainfall data
- Windrose maps
- Seismic data
- Road maps

Source: *Municipal Solid Waste Management Manual, India, 2016*

Field visit for local verification and identification of potential sites

- All features observed in various maps will be confirmed during the site visit.
- The possible sites should be evaluated on the basis of the topographical conditions and the suitability of the landfill site, namely:

a) Sufficient land size

b) Flat area with low inclination

c) Connection to highways and conditions of the access roads;

d) Flooding during monsoons

e) Land use and soil type

f) Depth to groundwater table (as observed in open wells or bore wells)

g) Information on the sub-ground from clay, stone, or sand pits

h) Crossing of electrical lines

i) Actual settlement patterns (eventual new or informal settlements)

***Source**: Municipal Solid Waste Management Manual, India, 2016*

Selection of best ranked sites

- The selection of most appropriate sites based on a Site Sensitivity Index based on the guidelines given by CPCB, in 2003, is done.
- The identified sites are ranked on the basis of a defined criteria for the preliminary environmental impact investigation and final site selection.

Preliminary environmental impact investigation

- Two or three sites may be chosen for a preliminary environmental impact investigation on the basis of ranking scores.
- The impact of the sanitary landfill will be assessed and potentially quantified according to the national rules and the local conditions.

***Source**: Municipal Solid Waste Management Manual, India, 2016*

Final site selection

The final selection of the site from amongst the best-ranked alternatives should be done by comparing:

a) Environmental impact

b) Social acceptance

c) Land availability

d) Transportation costs

e) Sanitary landfilling costs (site specific costs are to be considered)

LANDFILL SITE PREPARATIONS

1. Drainage away from landfill
2. Excavation
3. Placement of monitoring equipment (monitoring should be done 20-25 years after site closure)
   - Groundwater quality
   - Air quality

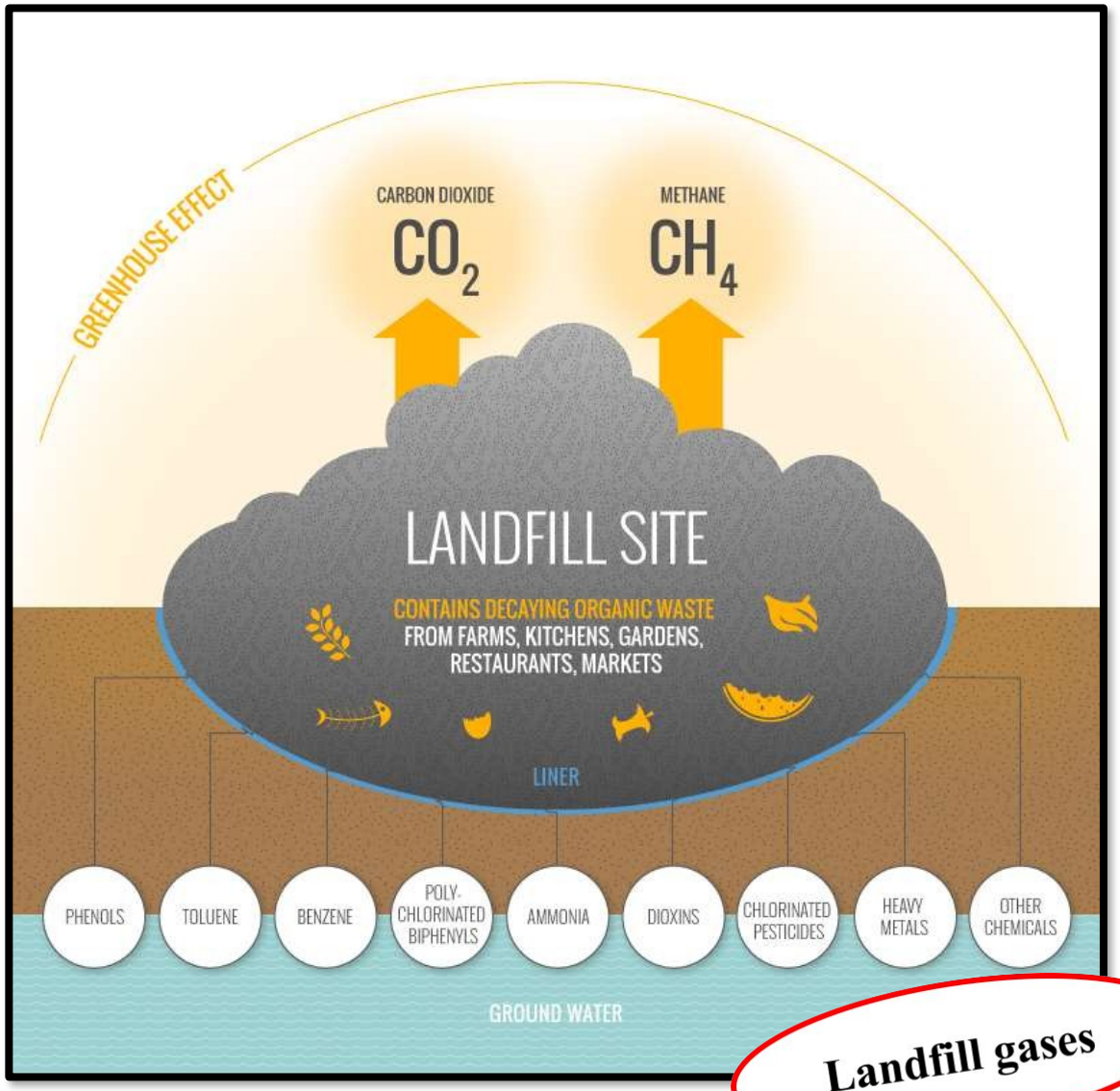
Source: *Municipal Solid Waste Management Manual, India, 2016*

Lecture 34
Leachate Collection and Treatment

THE TWO MOST COMMON PROBLEMS WITH LANDFILL

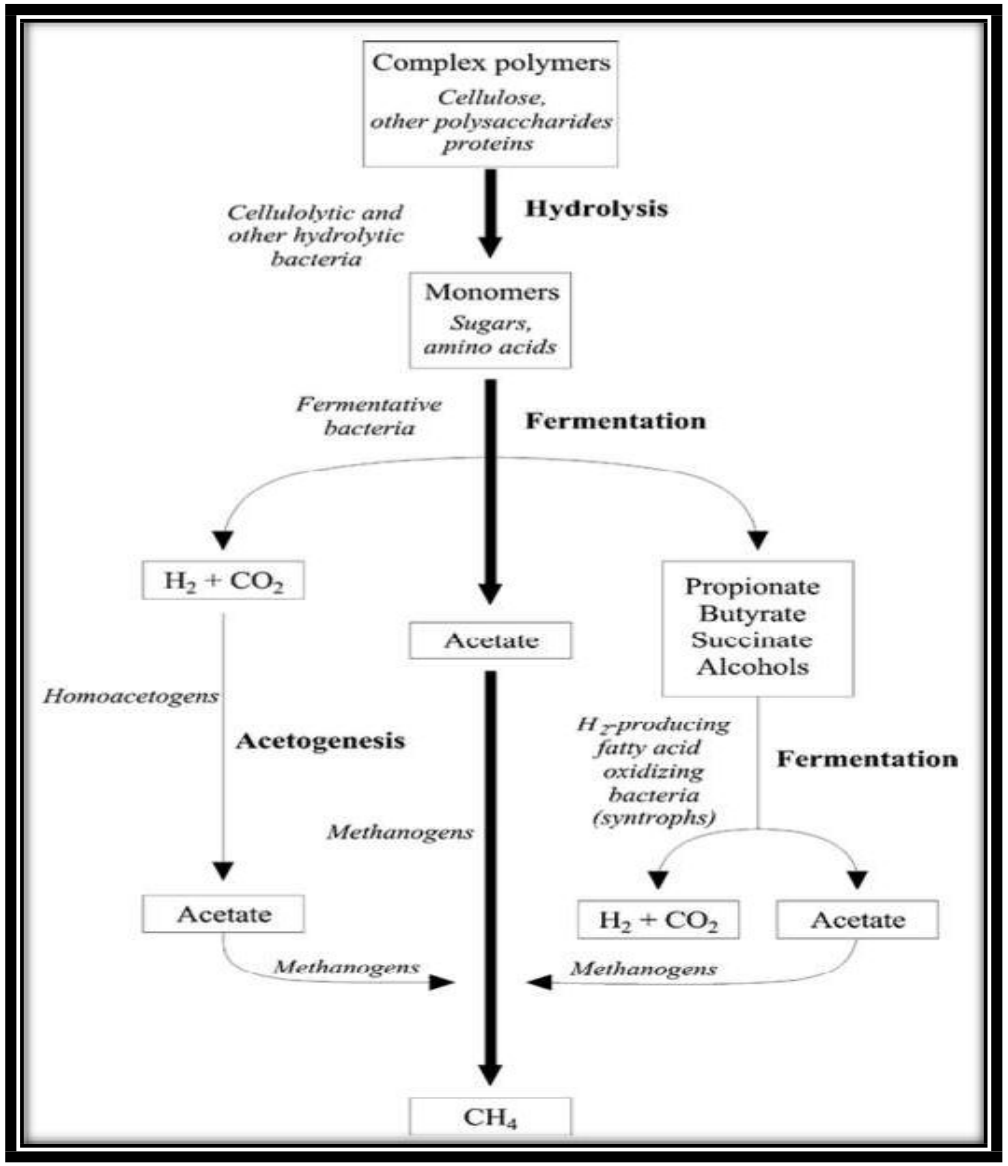
Landfill gases

- Organic materials such as wet vegetable, kitchen, waste (i.e., yard etc.) are usually compacted when they are put in to landfill.
- The problem is that, this removes oxygen and causes that material break down anaerobically.
- Over time, the process will produce methane: a type of greenhouse gas which is 28 times more potent than carbon dioxide.



Landfill gases

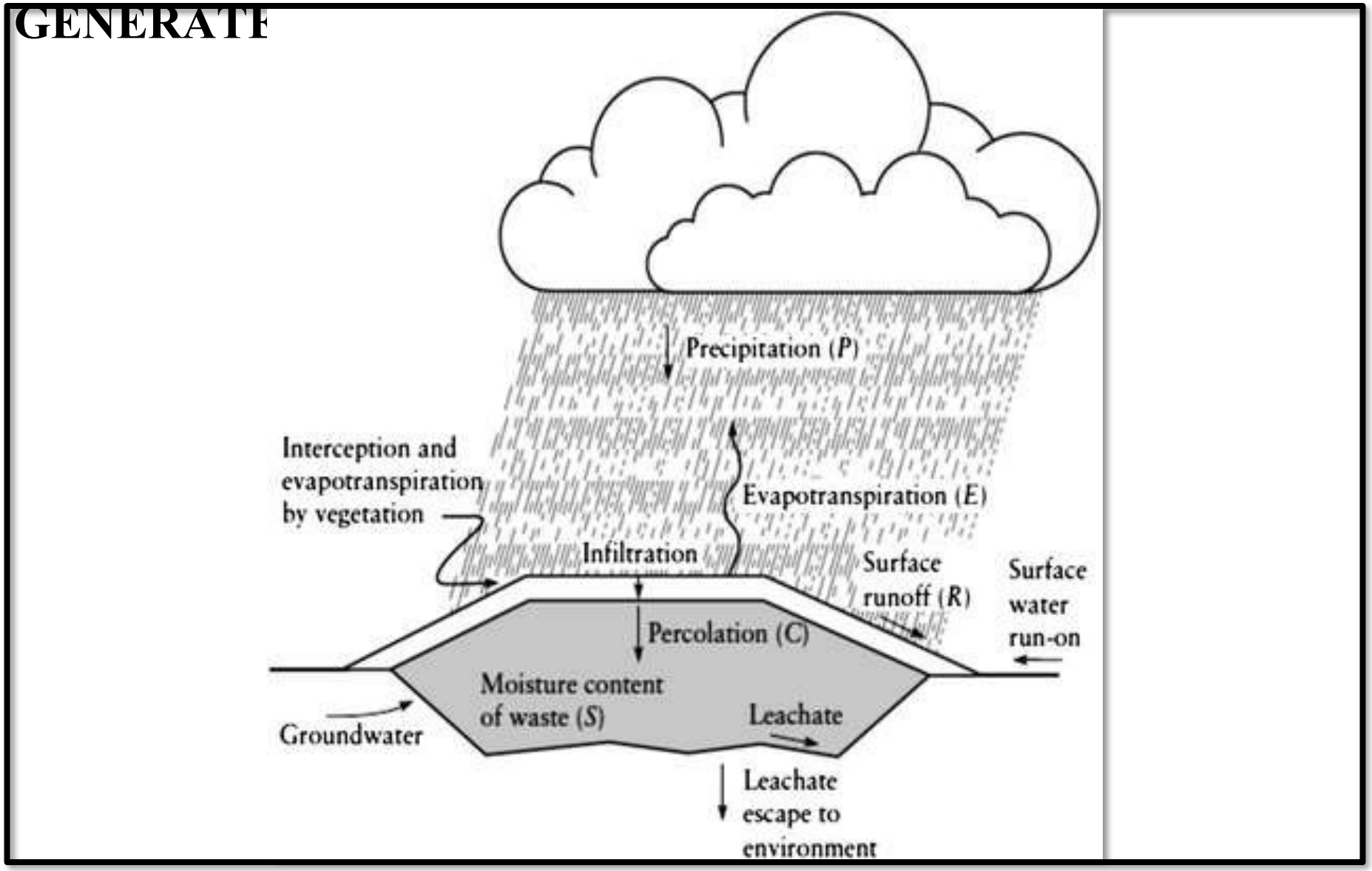
REACTIONS OCCURRING IN LANDFILLS



FACTORS INFLUENCING LEACHATE GENERATION

- Leachate varies widely depending on-
  - ✔ Age of the landfill
  - ✔ Type of waste (composition)
  - ✔ Environmental conditions
- Factors which influences the generation of leachate-
  - ✔ Infiltration of ground water
  - ✔ Infiltration of leachate in to the ground (a potential pollution of the ground water)
  - ✔ Rainfall (precipitation)
  - ✔ Water from the deposited waste, mainly due to biodegradation process

SCHEMATIC SCHEME OF HOW LEACHATE IS GENERATE



FACTORS THAT INFLUENCE LEACHATE QUALITY

- **Refuse composition:** Quality variation is higher for putrescible waste than for non- putrescible waste.
- **Elapsed time:** Leachate quality varies with time. In general overall quality of leachate generated in 1 year will be less strong than subsequent years.
- **Ambient temperature:** The ambient temperature affects both bacterial growth and chemical reactions.
- **Available moisture:** water plays a significant role in biodegradation and subsequent leaching of chemicals out of a waste.
- **Precipitation:** The amount of rain falling on landfill influences the leachate quantity significantly.
- **Ground water intrusion:** Sometimes landfill base construction below the ground water table, may increase quantity.
- **Moisture content of waste:** Leachate quantity will increase because of own self weight, the waste releases pore water when squeezed.

LEACHATE COLLECTION SYSTEM (LCS)

In a typical design the leachate collection system is a combination of-

- Main drain
- Side drain
- Perimeter drain
- Drain and protective layer
- Leachate wells-typically with pumps

Leachate problems:

✔ Clog up with silt or mud and growth of microorganisms in the pipes

✔ Chemical reaction leading to precipitation of minerals in the pipes

✔ The pipes become weakened by chemical attack (acids, solvents and oxidizing agents)

ROLE OF LCS COMPONENTS

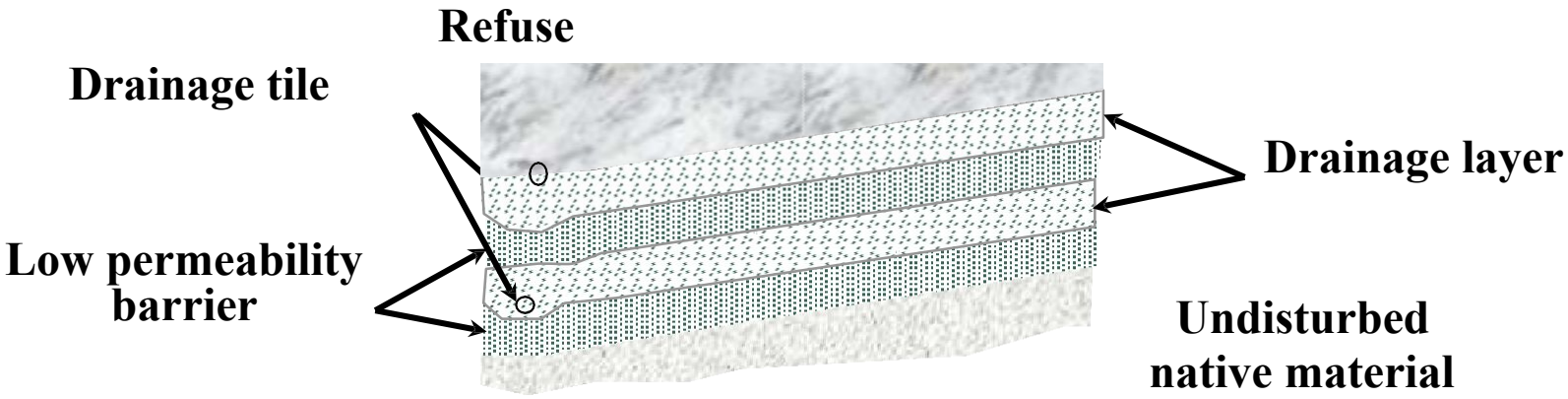
- **Barrier layer**: a very low-permeability synthetic or natural soil liner to restrict and control the rate of vertical downward flow of liquids.
- **Drainage layer**: a high permeability gravel drainage layer to laterally drain the liquid to the collector drain pipes; at least 30 cm thick with a min. K of 10^{-3} cm/sec.
- **Slope**: to encourage lateral migration; min. 2% bottom final slope after long-term settling.
- **French drains and tiles**: maximize the amount of leachate diverted to, and collected by the tile drains; sub angular gravel with UC < 4 and max. Φ of 2 in.; two or more rows of holes at the 2 and 10 o'clock positions; min. slope of 0.5% and min. Φ of 6 in.
- **Filter layer**: granular or synthetic, used above the drainage layer to reduce the potential for migration of fines into the drainage layer.
- **Fine soil or refuse**: K of 10^{-4} cm/sec; 2 ft (0.7 m) thick layer to cushion the engineered system against damage and act as a filter.

LEACHATE COLLECTION

Geomembrane Clay liner (3 ft) Slotted leachate collection pipe

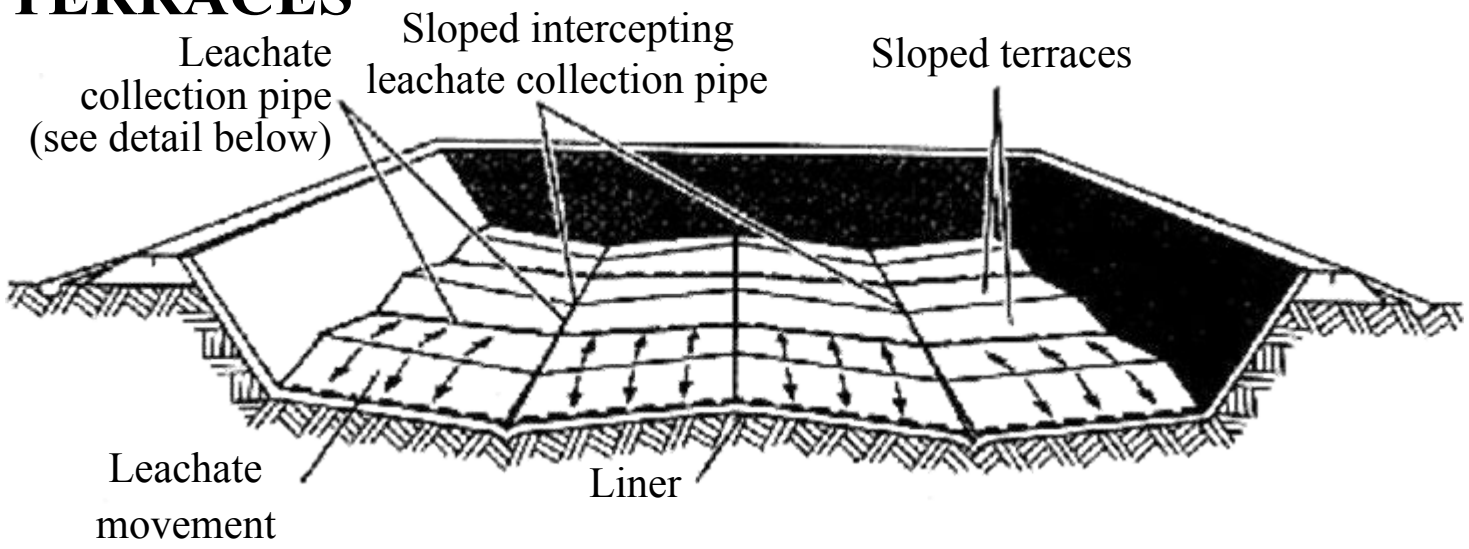
OUTLINE OF LEACHATE COLLECTION SYSTEM

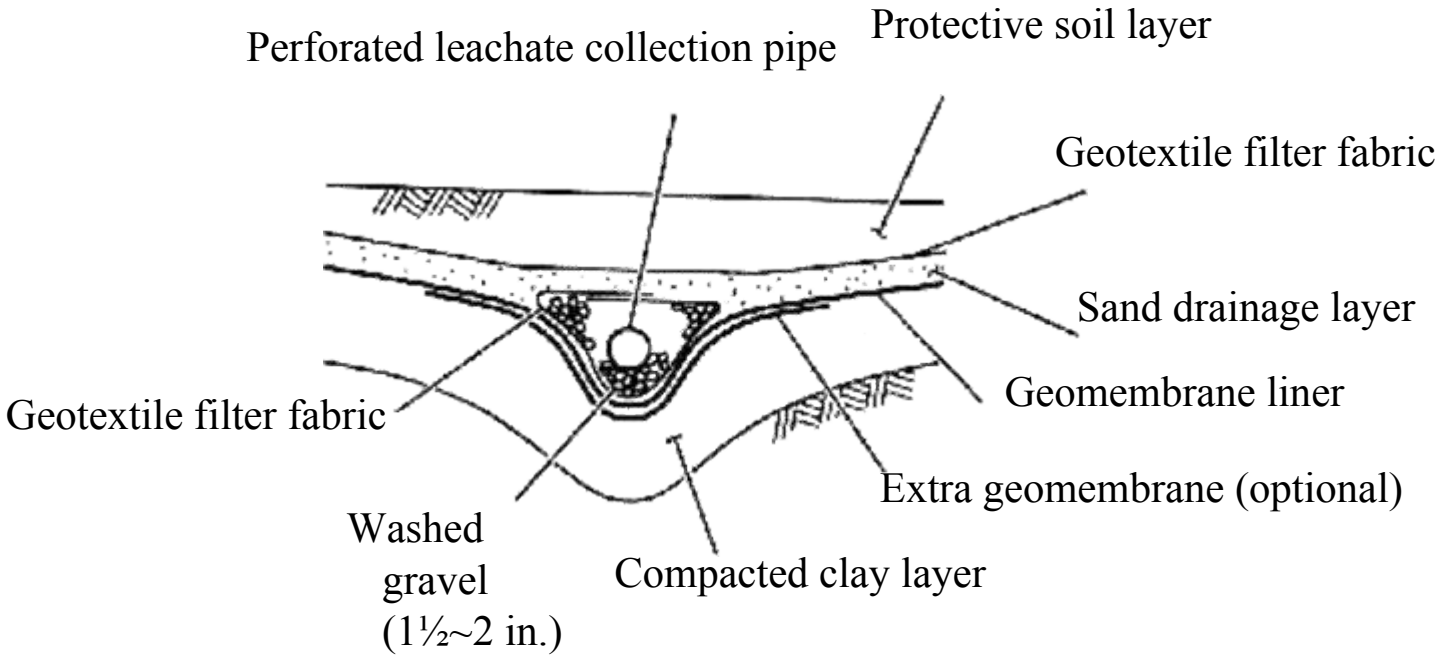
Simple collection system



Double liner system

LEACHATE COLLECTION SYSTEM WITH GRADED TERRACES





LEACHATE PONDS OR LAGOONS

- Lined leachate pond or lagoons are commonly used at landfill sites.
- The double liner is used at the bottom of the liner as a barrier layer with a leak detector might be employed.
- Aerators are provided as initial leachate treatment to reduce odor issues.

Leachate Ponds

LEACHATE STORAGE TANKS

- Leachate storage tanks or structural basins, with primary construction materials including steel, fiber glass and concrete.
- Storage tanks are remain open to the atmosphere and often include manifold diffuses of air addition.

Fiber glass leachate storage tank

Glass lined steel leachate storage tank

LEACHATE CONTROL

- The best way to control leachate in landfills are **strict storm water and runoff water**, **proper segregation of wet and dry waste** and **aerobic landfill technology**.

- To restrict the storm and runoff water, use proper liner system.
- Sorting into waste categories like wet (food ,vegetables) and dry waste (plastic, paper, wood etc..), leads to reduce leachate generation from the landfills.

Wet waste

Composting

RECYCLE PLANT

Solid Inert material

DESIGN OF LANDFILL LINERS

Liner is used as a control for leachate

- **Geotextile:** Thin synthetic material used to minimize the intermixing of the soil and sand or gravel layers.
- **Geonet:** Together with geotextile the drainage layer to convey leachate to the leachate collection system.
- **Geomembrane:** Synthetic material which serves as an impervious barrier to the movement of leachate and landfill gas.
- **Clay** liners may crack due to desiccation and it needs to be ensured that clay doesn't dry out as it is being placed.

ASPECTS FOR LEACHATE TREATMENT PLANT

- Limiting concentrations
- Low demand of resources
- Low demand of energy
- Low generation of residues, especially hazardous wastes
- Low environmental impact
- Economical efficient operation

THANK YOU