

# Solid waste management II

# Today's lecture

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- Solid waste management
  - Recycling
  - Composting
  - Incineration
  - Sanitary landfill

# Reduce, reuse and recycling (3R)

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- Reduce: minimize the production of wastes (most preferred)
- Reuse: use products or materials again for the same purpose for which they are intended
- Recycle: collect used, reused, or unused items, make them into raw material, and re-manufacture the raw material into new products

# Recycling

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- Closed-loop (primary) recycling
  - Use of recycled products to make the same or similar products
  - Example: use of used glass bottles to make new glass bottles
- Secondary recycling
  - Use of recycled products to make new products with different characteristics than originals
  - Example: use of polyethylene milk jugs to make toys
- Tertiary recycling
  - Use of recycled products to recover chemicals or energy
  - Example: recovery of solvents from manufacturing with distillation so they can be reused in same or other operations

# Composting

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- Controlled decomposition of organic materials such as plant materials, animal waste, food waste, and wastewater sludge by microorganisms
- By the composting process, the microorganisms degrade easily degradable organic materials, odor-generating compounds, and toxic compounds into stable and non-toxic materials
- The product is a crumbly, earth-smelling, soil-like material that can serve as carbon and nitrogen source for crops

# Incineration (combustion)

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- Definition: a chemical reaction in which the elements in materials are oxidized in the presence of excess oxygen
- Effective for reducing the amount of solid wastes
- Major elements to be oxidized: carbon and hydrogen (and some sulfur) → major product of oxidation: CO<sub>2</sub> and H<sub>2</sub>O (and some SO<sub>2</sub>)

# Incineration (combustion)

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- Advantages
  - Can minimize the solid waste generation → save landfill space (good when land use is restricted)
  - Can recover heat (energy) from waste if the waste has a relatively high heating value
- Disadvantages
  - Requires additional energy input if wastes have low heating value
  - Health and environmental issues
    - Emission of air pollutants such as particulates, acid gases ( $\text{SO}_x$ , HCl, HF),  $\text{NO}_x$ , CO, organics, heavy metals
    - Emission of carcinogenic compounds such as dioxins and PAHs (polycyclic aromatic hydrocarbons)

# Sanitary landfill disposal

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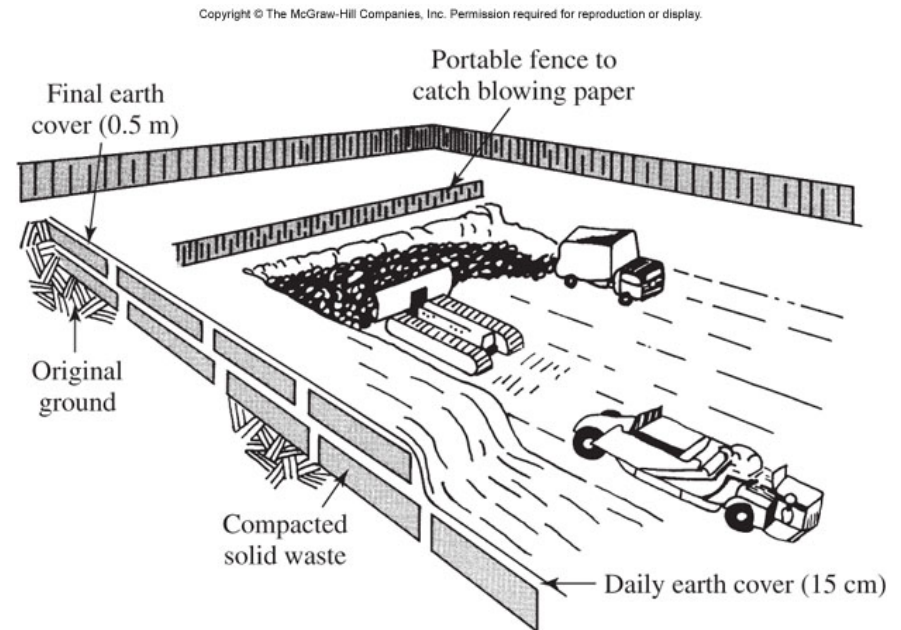
- Landfill of some solids wastes is inevitable
- Landfill site selection is not easy (esp. in Korea!)
- Things to consider for site selection
  - Restricted locations, including wetlands, flood plains, seismic impact areas
  - Public opposition
  - Proximity to major roadways
  - Load limits on roads and bridges
  - Underpass limitations
  - Traffic patterns and congestion
  - Location of groundwater table and sole-source aquifers
  - Soil conditions and topography
  - Availability of cover material
  - Climate
  - Zoning requirements
  - Buffer areas surrounding the site
  - Location of historic buildings, endangered species, and similar environmental factors



# Operation of sanitary landfills

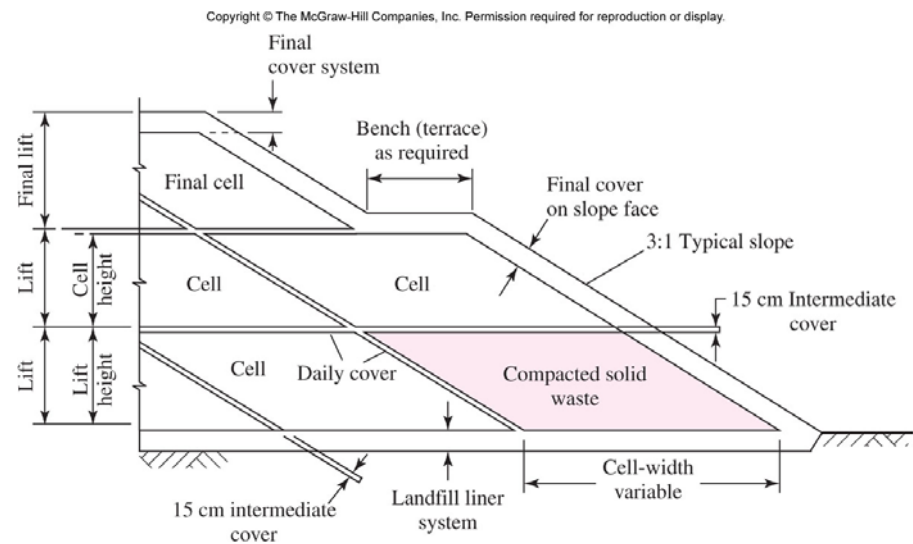
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- Area method
  - Most common method of operation
  - Three step process (usually done on a daily basis)
    - Spread the waste
    - Compact the waste
    - Cover the waste with soil (daily cover)



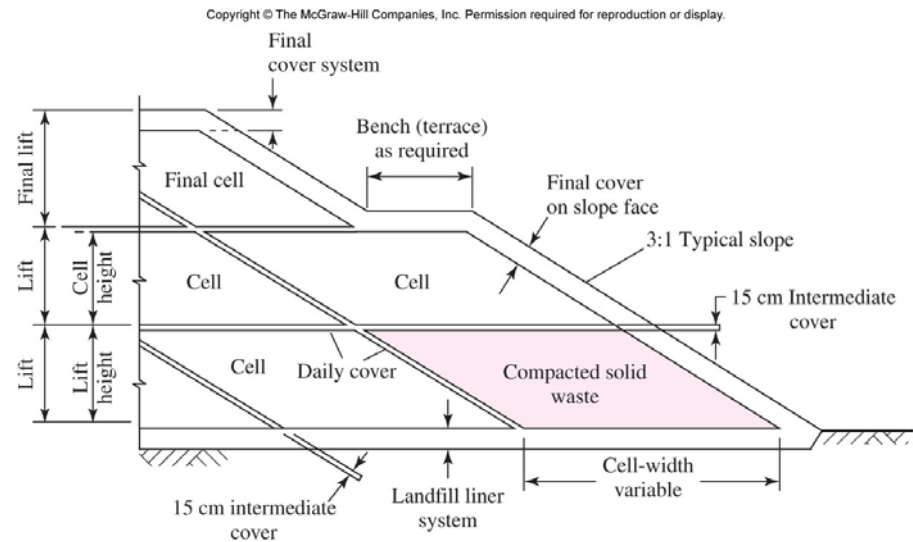
# Operation of sanitary landfills

- Area method
  - The waste and daily cover placed in a landfill during one operational period (commonly one day) form a **cell**.
  - The waste is dumped onto the working **face**.
  - A **lift** refers to the placement of a layer of waste or the completion of a horizontal active area of the landfill



# Operation of sanitary landfills

- Area method
  - The first lift is called a **fluffy lift** because the waste is not compacted until 2 m of waste is deposited. This is done to protect the liner.
  - **Benches** are used where the height of the landfill > 15-20 m.
  - The **final cover** is applied after all land-filling operations are complete.



# Landfill leachate

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- Leachate is the liquid that passes through the landfill, extracting dissolved and suspended matter from the landfill.
- The liquid enters the landfill from rainfall, surface drainage, groundwater or is present or produced within the landfill.
- The leachate usually has a high BOD and COD, ammonia, and may contain heavy metals. The characteristics of the leachate vary with age.

# Landfill leachate control

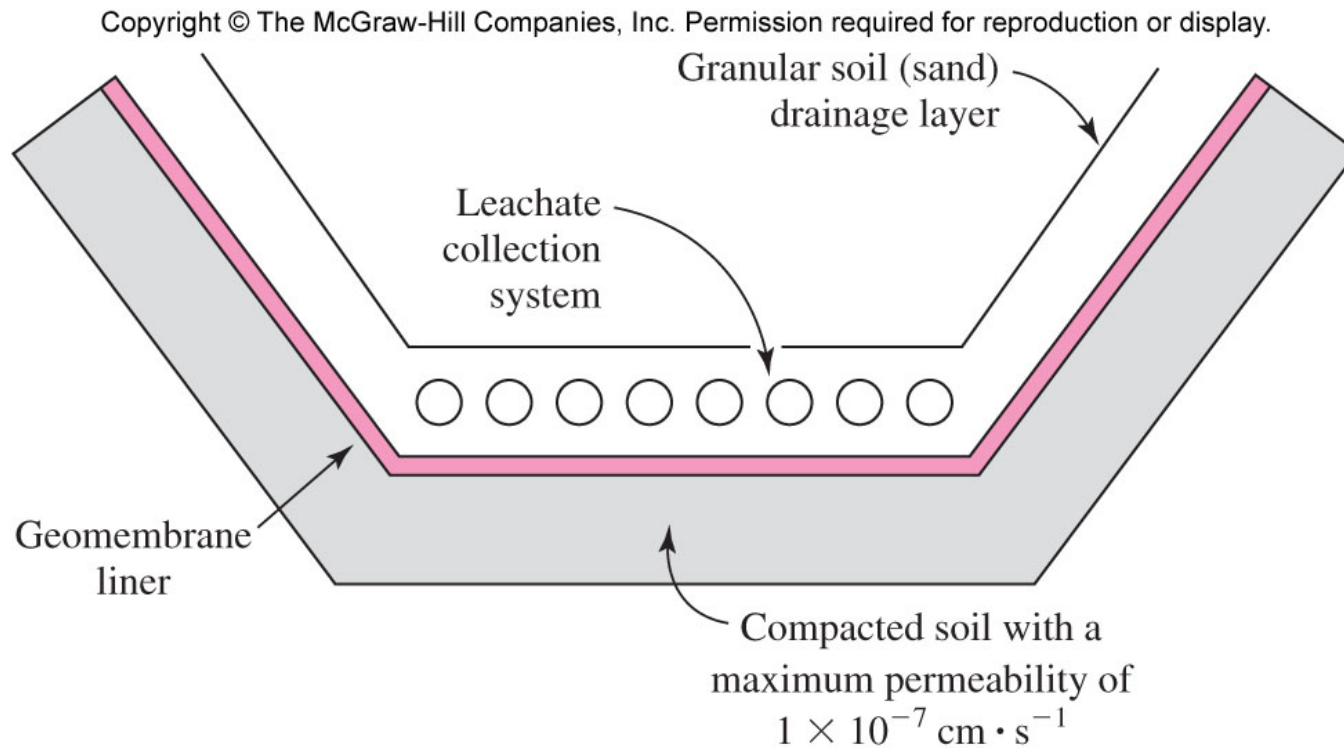
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- Landfill must be designed to prevent the seepage of leachate from the landfill into underground and finally to groundwater
- The leachate is collected to the ground and treated
- The final cover must also prevent the seepage of surface water to landfill

# Landfill leachate control

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- Landfill liner to prevent seepage of leachate



# Landfill gas control

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- Landfill produces  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{NH}_3$ , and other toxic trace gases
- High  $\text{CH}_4$  content (45-60%) – explosive, greenhouse effect, damage crops
- So, landfill gas collection systems should also be installed
- Treatment of landfill gas
  - Recover  $\text{CH}_4$  for fuel
  - Combustion to  $\text{CO}_2$

# Reading assignment

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Textbook Ch 13 p. 661-686