Solid waste management

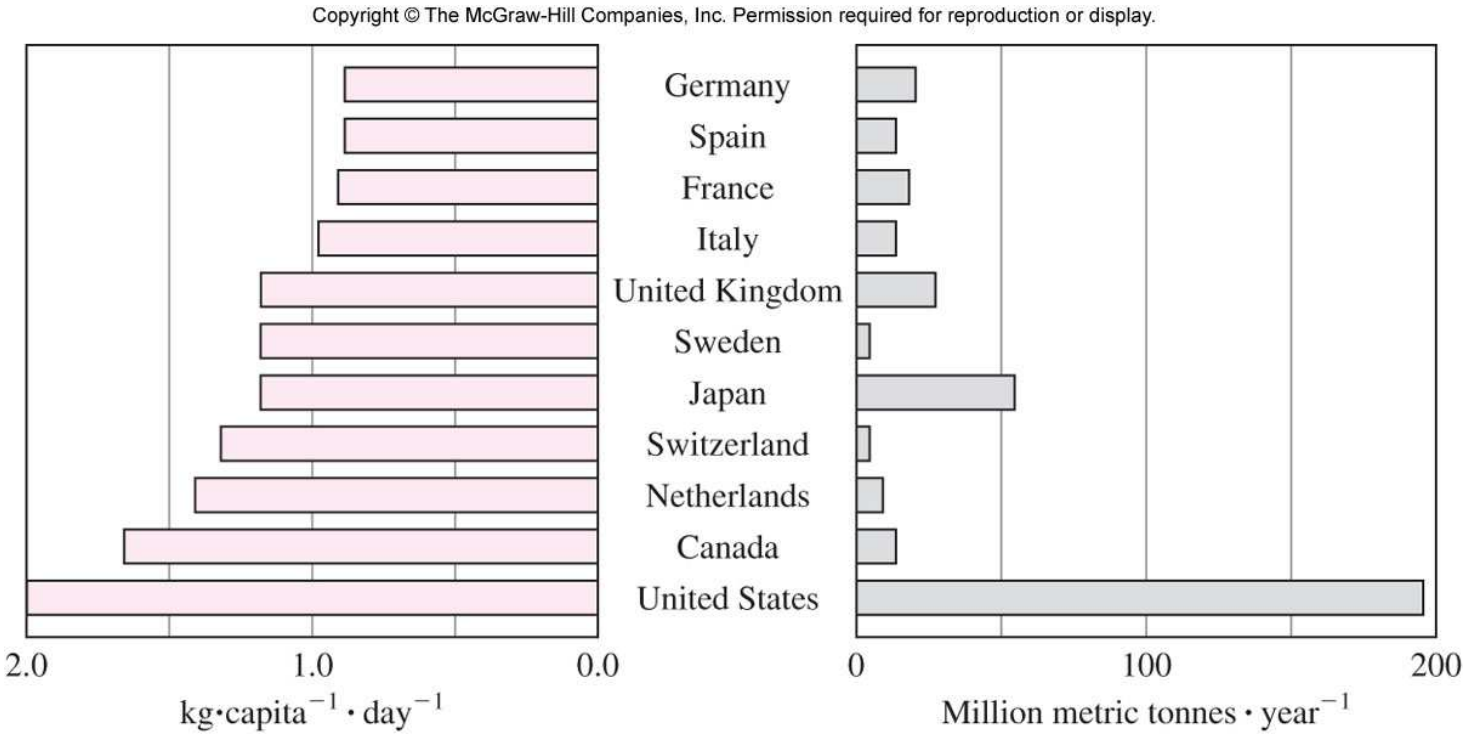
Solid waste management

- Magnitude and sources of solid wastes
- Classification of solid wastes
- Fate of solid wastes
- Solid waste management
  - Recycling
  - Composting
  - Incineration
  - Sanitary landfill

Solid waste

- Things we throw away
- Called garbage, refuse, trash (쓰레기, 폐기물)

Magnitude of the problem



(2010)

Korea: 0.95 kg·capita^{-1}·day^{-1} (2012)

Sources of solid wastes

Source	Typical facilities, activities, or locations
Residential	Homes
Commercial	Stores, restaurants, markets, office buildings, hotels, etc.
Institutional	Schools, hospitals, prisons, government buildings
Construction	New construction sites, road repair sites, demolition of buildings
Municipal services	Street cleaning, landscaping, parks and beaches, waste and wastewater treatment processes
Industrial	Construction, fabrication, manufacturing, refineries, chemical plants, power plants
Agricultural	Crop field, rice paddies, orchards, animal farms

Classification of solid wastes

- The regulation, classification, and management of solid wastes varies for different countries
- 우리나라 폐기물 관리체계
  - 배출원(source)에 따라
    - 가정생활계폐기물
    - 사업장폐기물
  - 유해성(hazard)에 따라
    - 일반폐기물
    - 지정폐기물

Classification of solid wastes

- 배출원 별 분류
  - 가정생활계폐기물
    - 일반폐기물: 종량제봉투에 수거
    - 재활용품: 종이, 금속류, 플라스틱, 비닐, PET, 스티로폼, 유리, 의류 등
    - 음식물류: 별도 종량제봉투에 수거
    - 대형폐기물: 가구, 전자제품 등 – 신고 후 별도로 수거

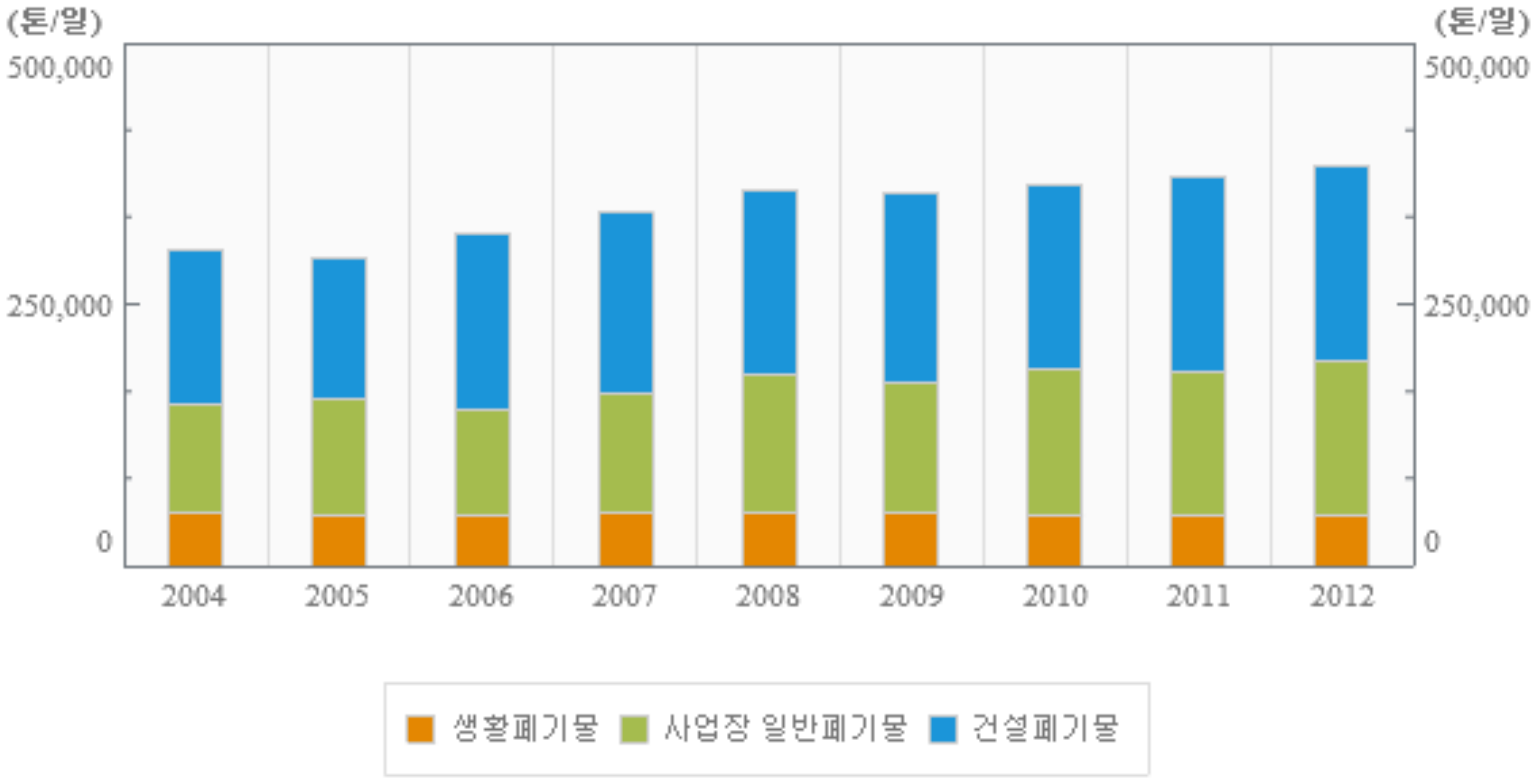
Classification of solid wastes

- 배출원 별 분류
  - 사업장폐기물
    - 사업장생활계폐기물: 사업장(공장, 학교, 식당, 병원, 관공서 등)에서 매일 발생되는 일반적 성상의 폐기물 (가정생활계폐기물과 성상 유사)
    - 사업장배출시설계폐기물: 지정된 배출시설에서 발생하는 폐기물 (시설에 따른 특이적인 성상)
    - 건설폐기물: 건설사업 또는 토목/건축구조물 철거에 따라 발생하는 폐기물

Classification of solid wastes

- 유해성에 따른 분류
  - 일반폐기물
  - 지정폐기물: 사업장에서 발생하는 폐기물로 상당한 환경 영향이 우려되는 폐기물
    - 폐산, 폐알칼리, 폐유, 폐유기용제, 폐고분자화합물, 석면, 광재, 분진, 소각잔재물, 오니류 등
    - 의료폐기물

Waste generation in Korea



Fate of residential daily wastes (Korea)

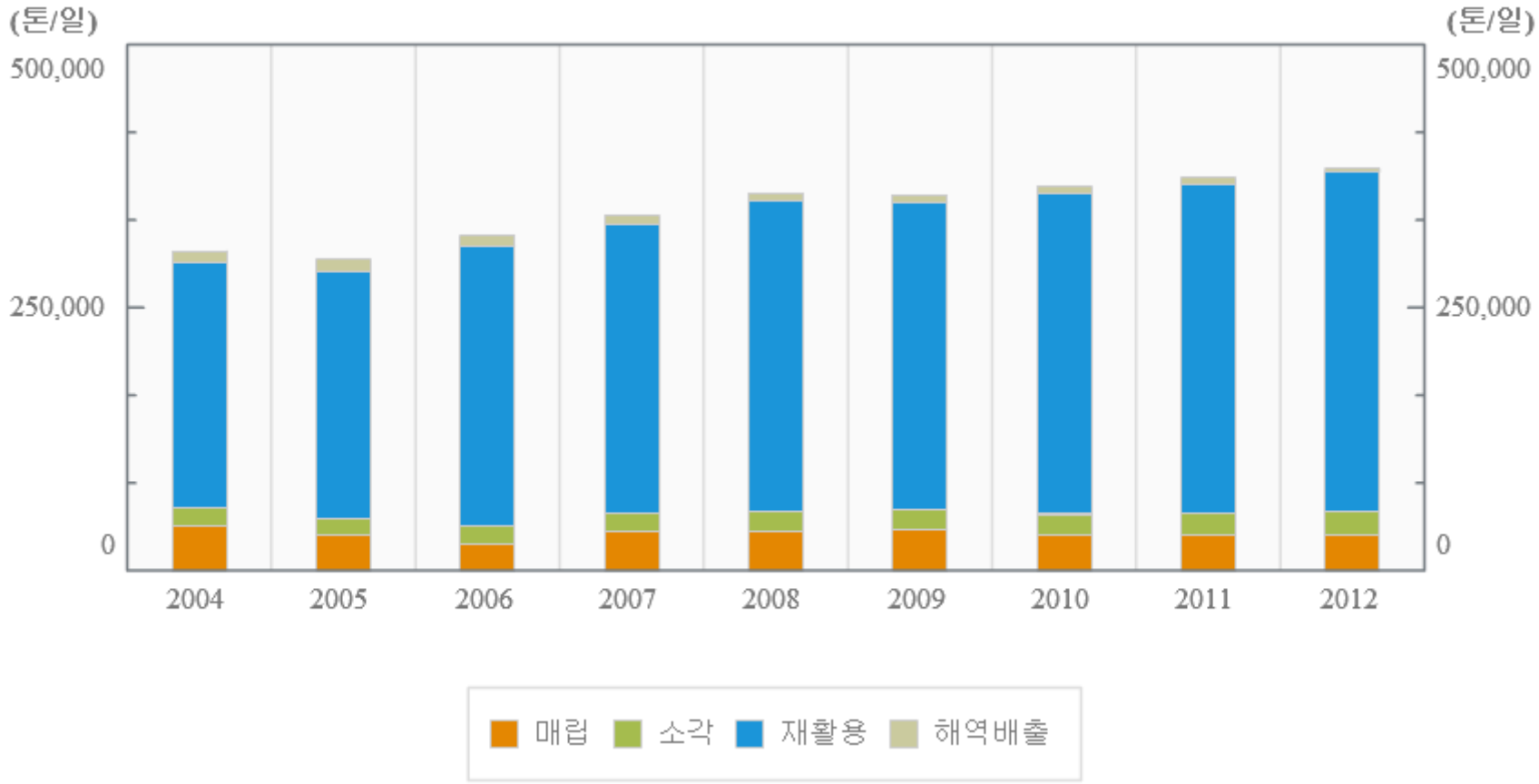
- 일반폐기물: collected by trucks → mostly landfilled or incinerated
- 재활용품: collected by trucks → recycling center for further classification → industrial consumers
- 음식물 폐기물: collected by trucks → food waste resource center (generate resources such as animal feed, compost, or fuel) → the resources are sent to consumers, and the final wastes are landfilled or incinerated

Fate of industrial & commercial wastes (Korea)

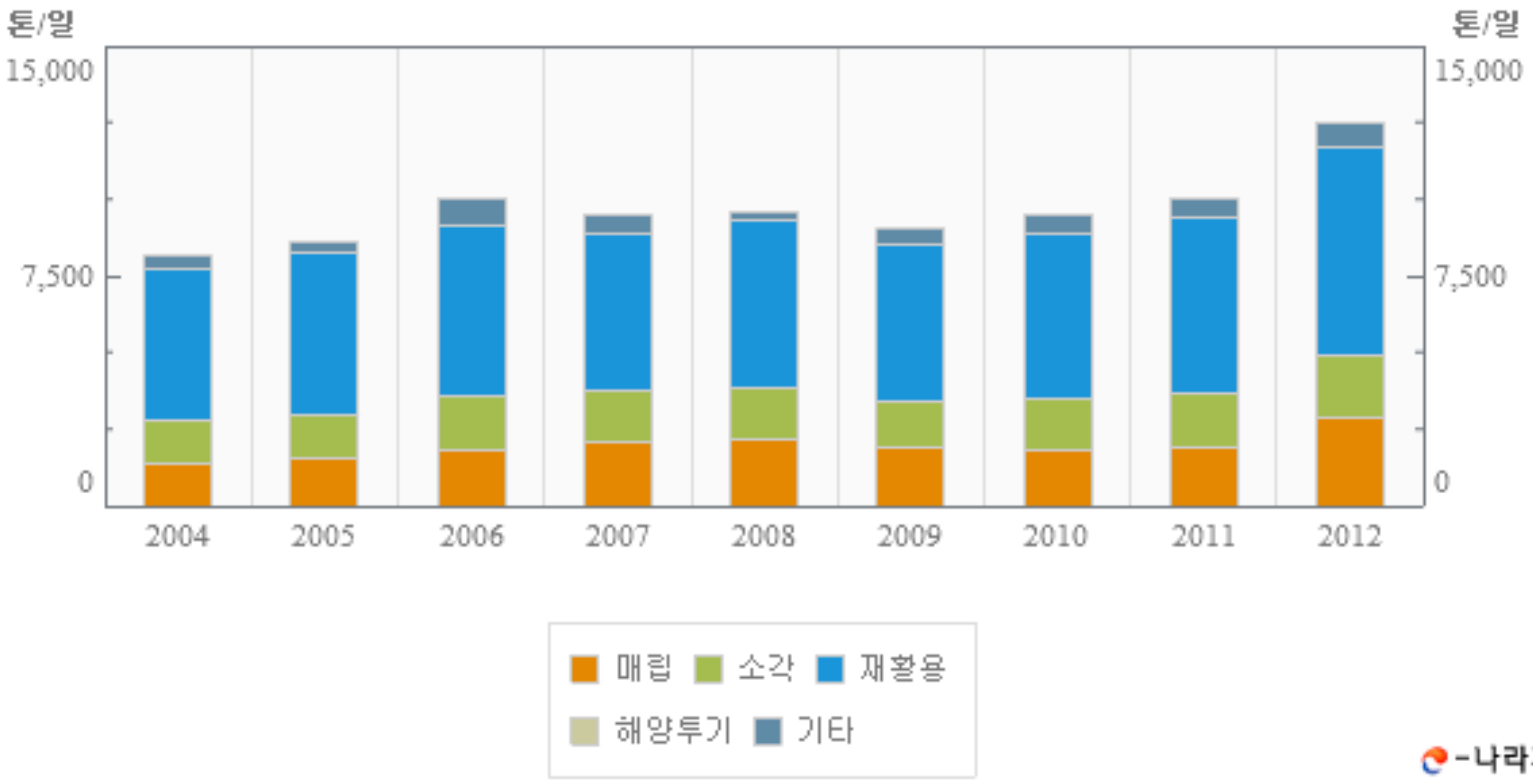
- 사업장생활계폐기물: combined with daily residential waste

- 기타 사업장생활계폐기물
  - 일반폐기물: mostly recycled (ex: construction waste – recycled as construction materials)
  - 지정폐기물: treated by specific procedures, recycled, incinerated or disposed in secure landfills (지정폐기물 매립지)

Statistics – fate of non-designated wastes in Korea



Statistics – fate of designated wastes in Korea



Reading assignment

폐기물관리법, 시행령, 시행규칙

(http://www.law.go.kr)

Reduce, reuse and recycling (3R)

- 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

- 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

- 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)

- 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_2 and H_2O (and some SO_2)

Incineration (combustion)

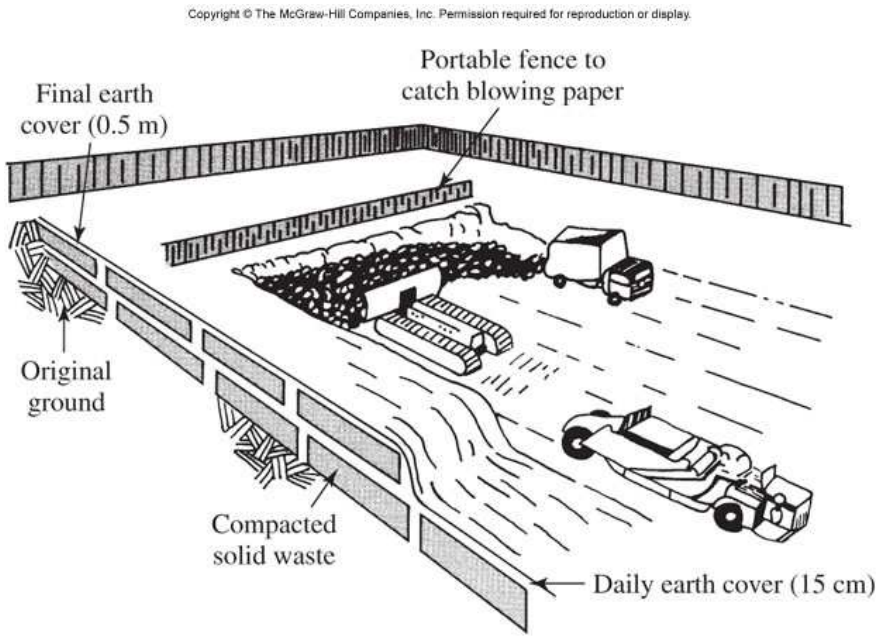
- Advantages
  - Can minimize the solid waste generation → save landfill space (good when land use is restricted)
  - Can recover heat (energy) from waste if the waste has a relatively high heating value
- Disadvantages
  - Requires additional energy input if wastes have low heating value
  - Health and environmental issues
    - Emission of air pollutants such as particulates, acid gases (SO_x, HCl, HF), NO_x, CO, organics, heavy metals
    - Emission of carcinogenic compounds such as dioxins and PAHs (polycyclic aromatic hydrocarbons)

Sanitary landfill disposal

- 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

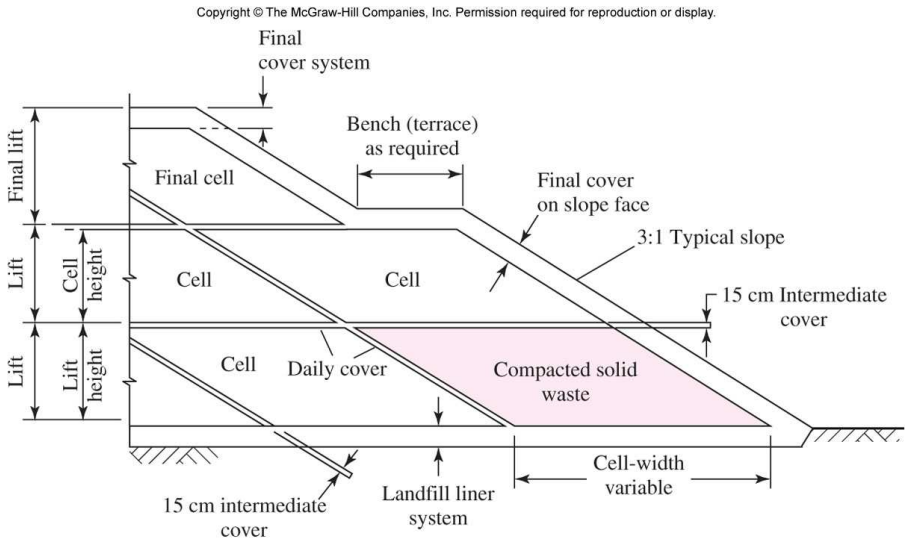
Operation of sanitary landfills

- 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)



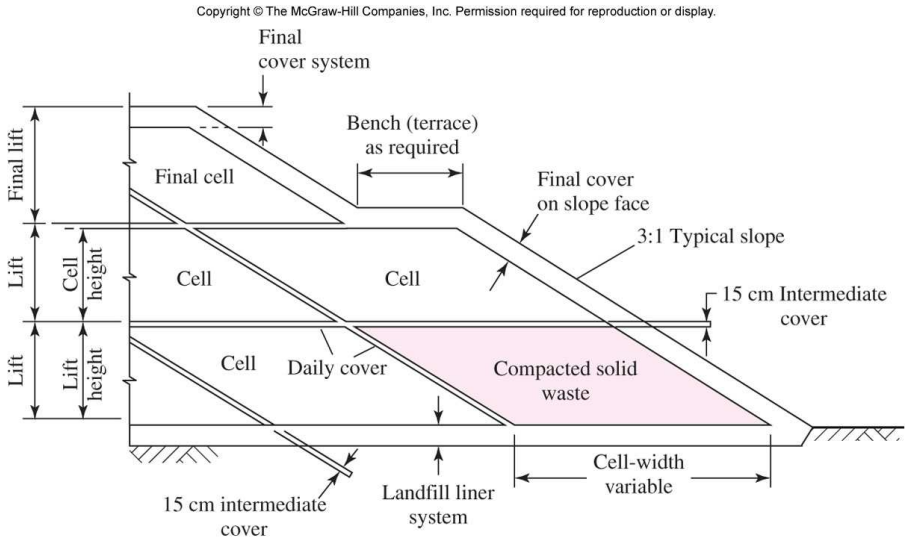
Operation of sanitary landfills

- 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

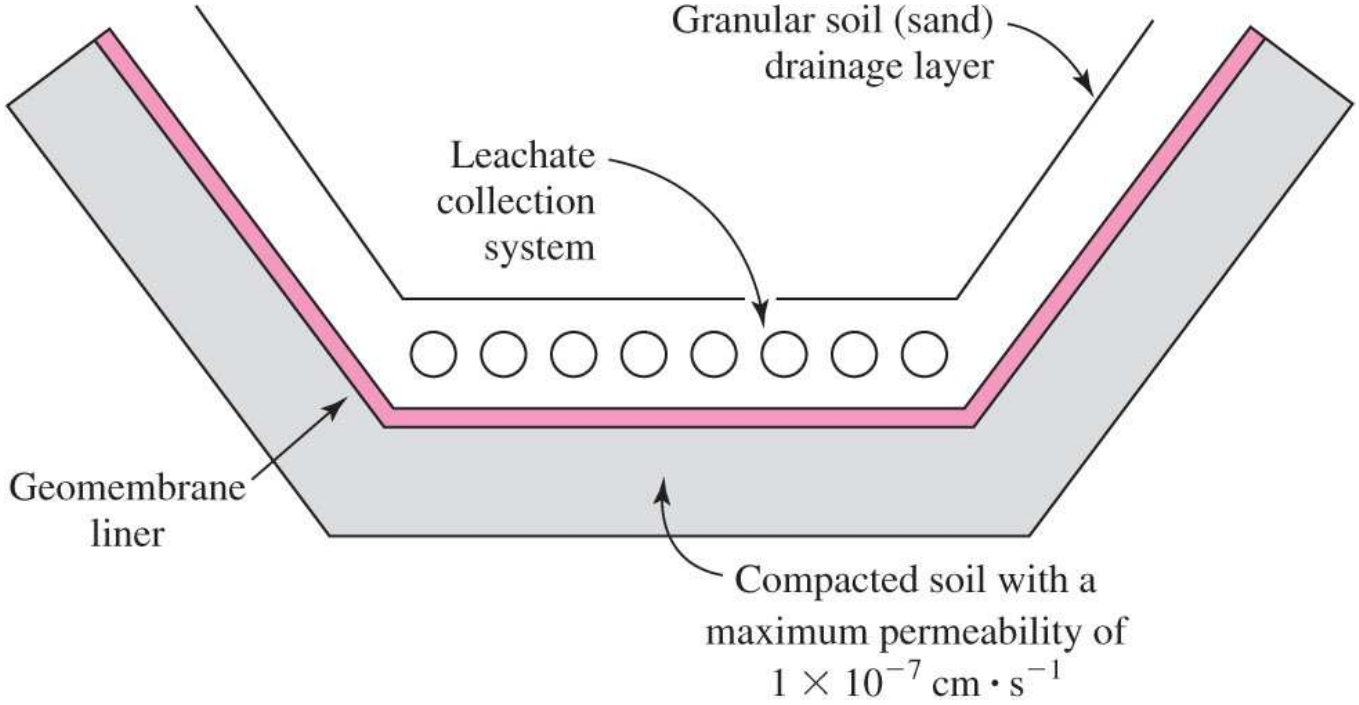
- Leachate is the liquid that passes through the landfill, extracting dissolved and suspended matter from the landfill.
- The liquid enters the landfill from rainfall, surface drainage, groundwater or is present or produced within the landfill.
- The leachate usually has a high BOD and COD, ammonia,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

Landfill leachate control

- 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

- Landfill liner to prevent seepage of leachate



Landfill gas control

- Landfill produces CO_2, CH_4, NH_3, and other toxic trace gases
- High CH_4 content (45-60%) – explosive, greenhouse effect, damage crops
- So, landfill gas collection systems should also be installed
- Treatment of landfill gas
  - Recover CH_4 for fuel
  - Combustion to CO_2

Reading assignment

Textbook Ch 13 p. 661-686