

Solid waste management

Solid waste management

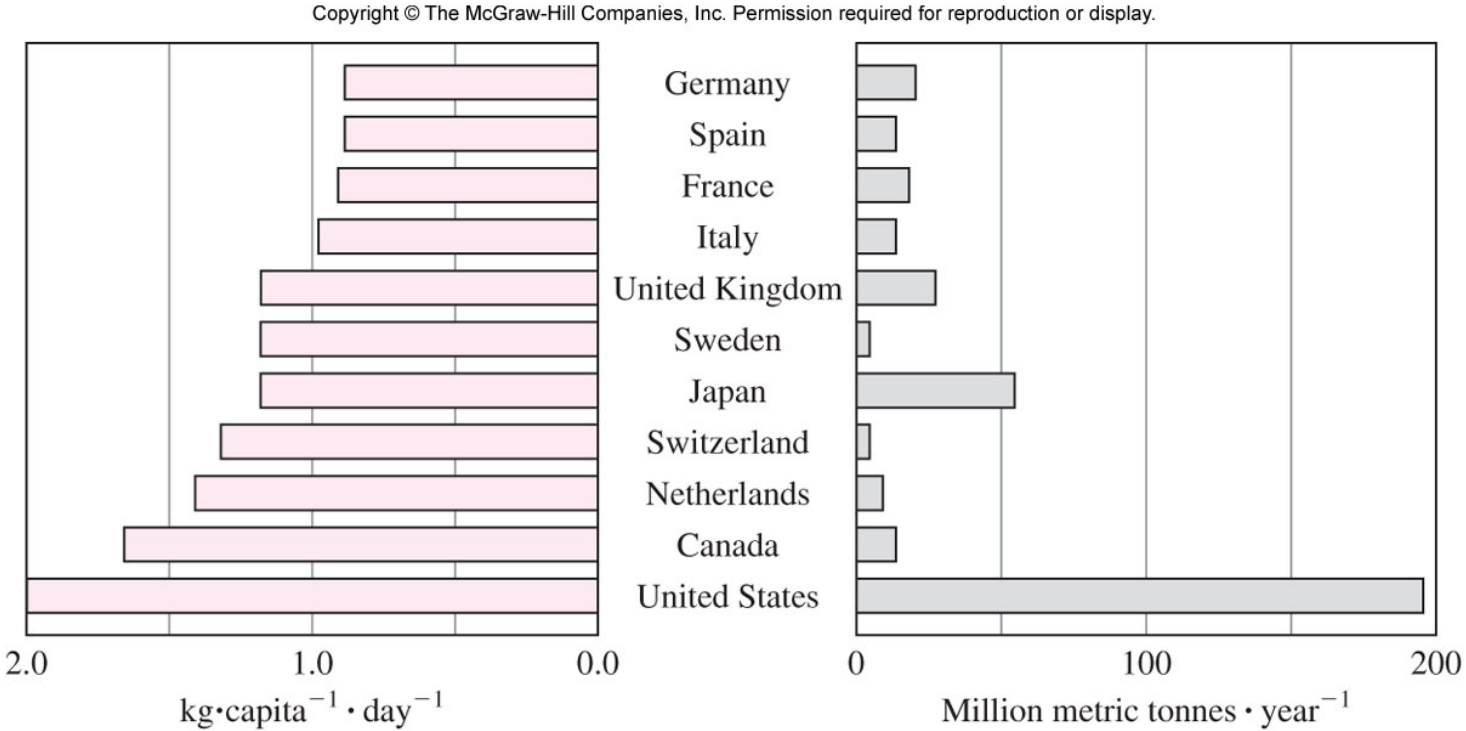
- Magnitude and sources of solid wastes
- Classification of solid wastes
- Fate of solid wastes
- Solid waste management
 - Recycling
 - Composting
 - Incineration
 - Sanitary landfill

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 분류체계



가정생활폐기물

- 재활용품: 종이, 금속류, 플라스틱, 비닐, PET, 스티로폼, 유리, 의류 등
- 음식물류: 별도 종량제봉투에 수거
- 대형폐기물: 가구, 전자제품 등 - 신고 후 별도로 수거
- 이외 폐기물: 종량제봉투에 수거

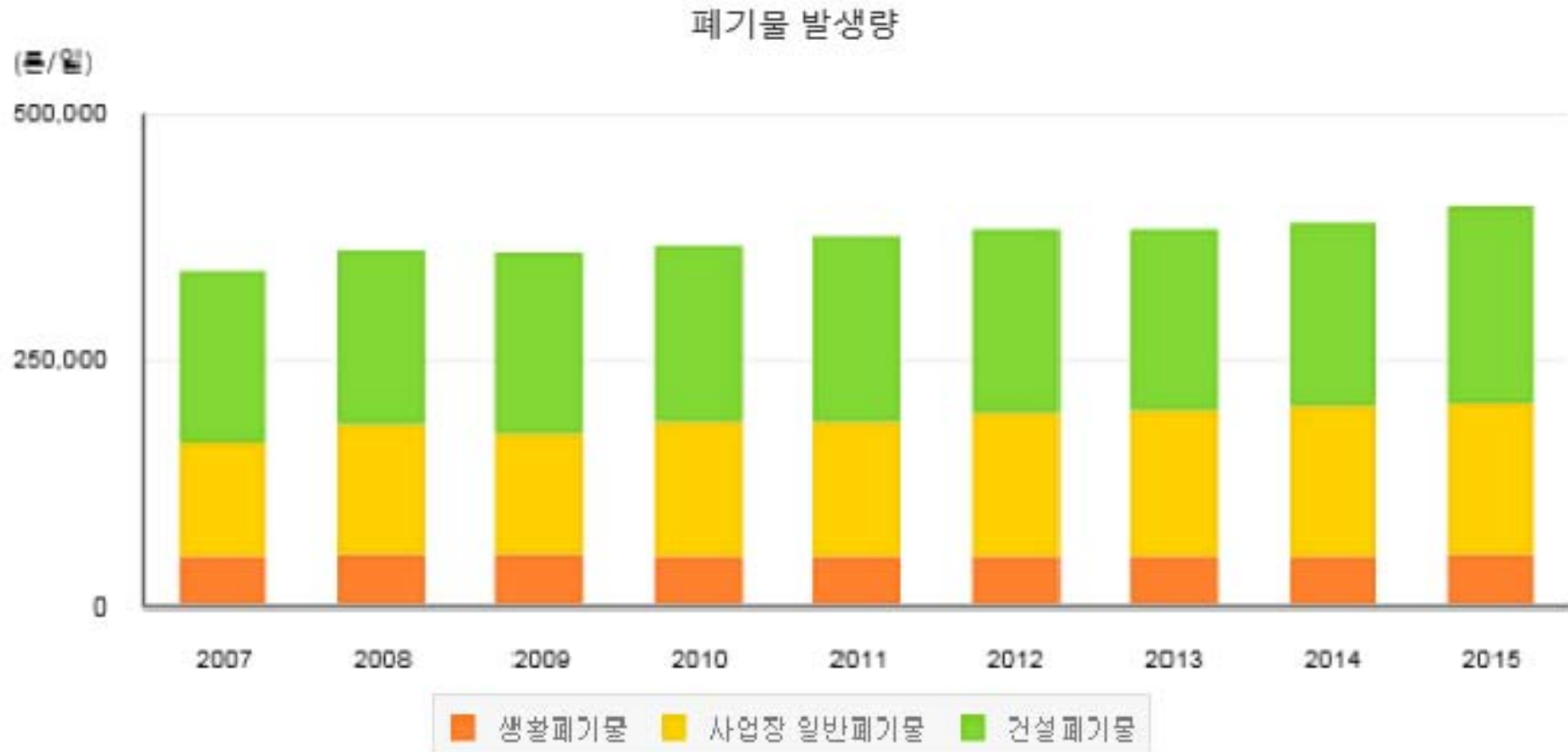
사업장폐기물

- 사업장일반폐기물
 - 사업장생활계폐기물: 사업장(공장, 학교, 식당, 병원, 관공서 등)에서 매일 발생하는 일반적 성상의 폐기물 (가정생활폐기물과 성상 유사)
 - 사업장배출시설계폐기물: 지정된 배출시설에서 발생하는 폐기물 (시설에 따른 특이적인 성상)

사업장폐기물

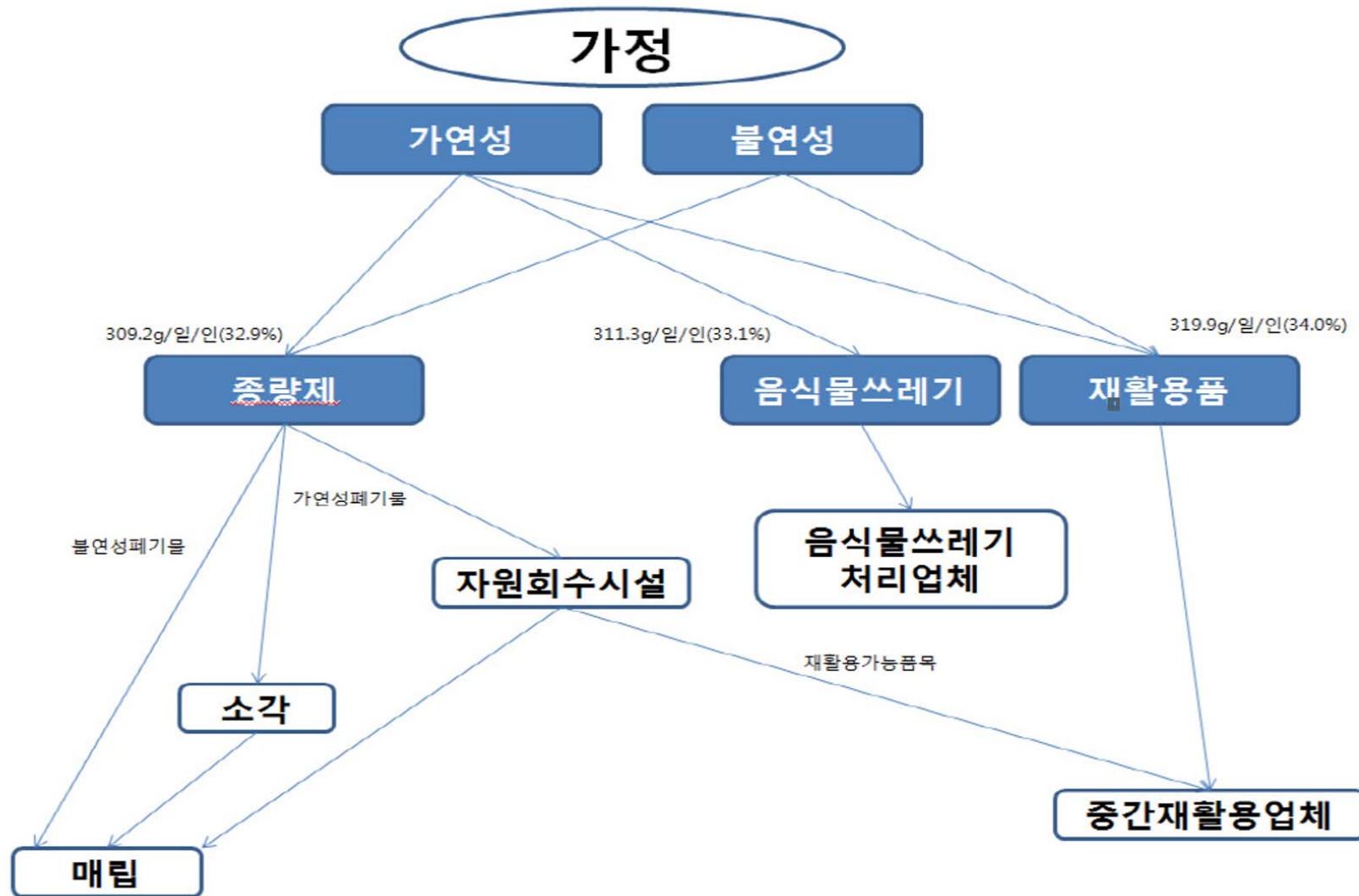
- 지정폐기물: 사업장에서 발생하는 폐기물로 상당한 환경 영향이 우려되는 폐기물
 - 폐산, 폐알칼리, 폐유, 폐유기용제, 폐고분자화합물, 석면, 광재, 분진, 소각잔재물, 오니류 등
 - 의료폐기물
- 건설폐기물: 건설사업 또는 토목/건축구조물 철거에 따라 발생하는 폐기물

일반폐기물 발생현황



e-나라지표, 2017

가정생활폐기물 배출·수거·운반·처리



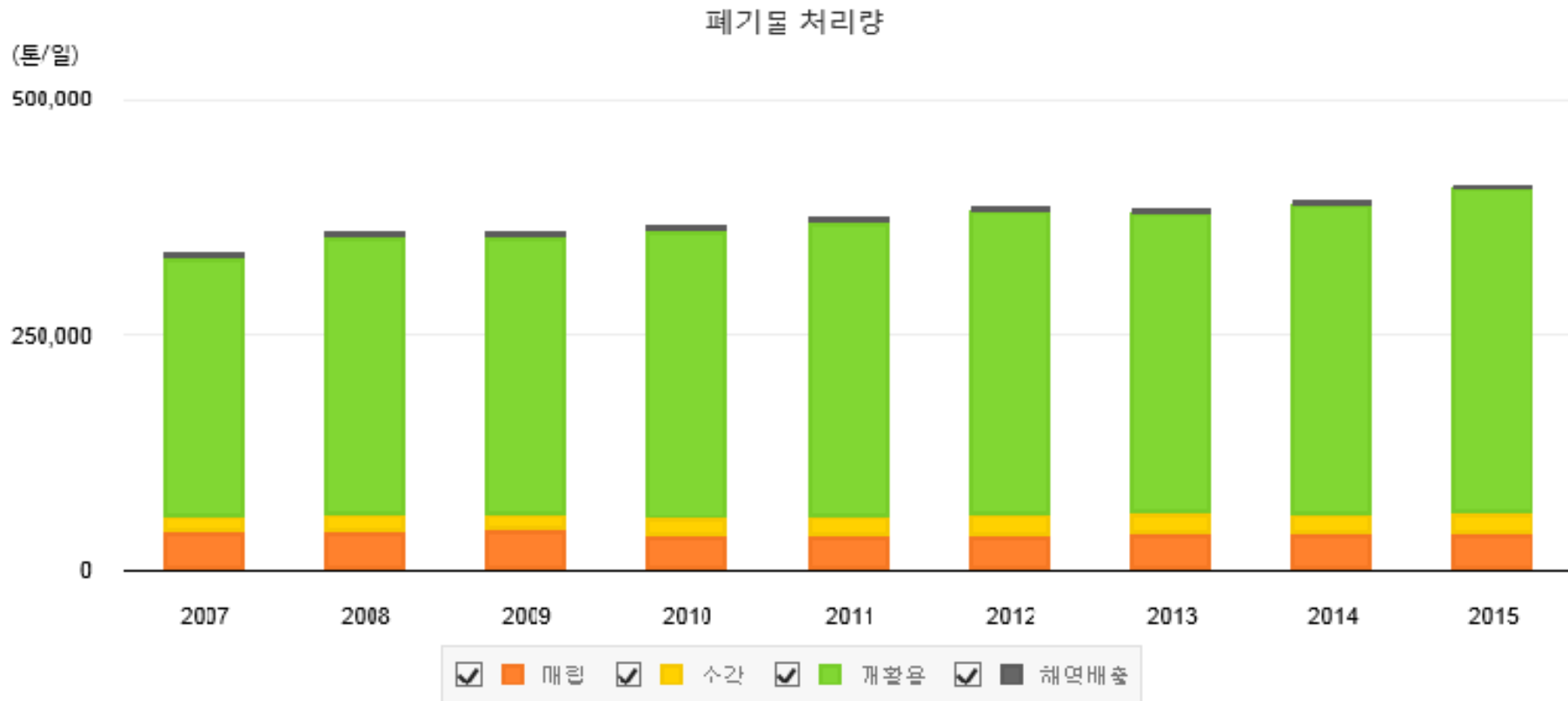
가정생활폐기물 배출·수거·운반·처리

- 종량제에 의한 혼합배출: 차량수거 →
[가연성] 재활용 가능항목을 분리하거나 소각한 후 매립
- 소각 시 열 회수, 난방활용
[불연성] 매립
- 재활용품: 차량수거 → 추가분리 → 재활용 업체 판매
- 음식물 폐기물: 차량수거 → 자원회수: 가축사료, 퇴비, 연료 등 생성 → 생산자원 소비자 공급, 최종 폐기물 소각 후 매립 또는 직매립

사업장폐기물 처리

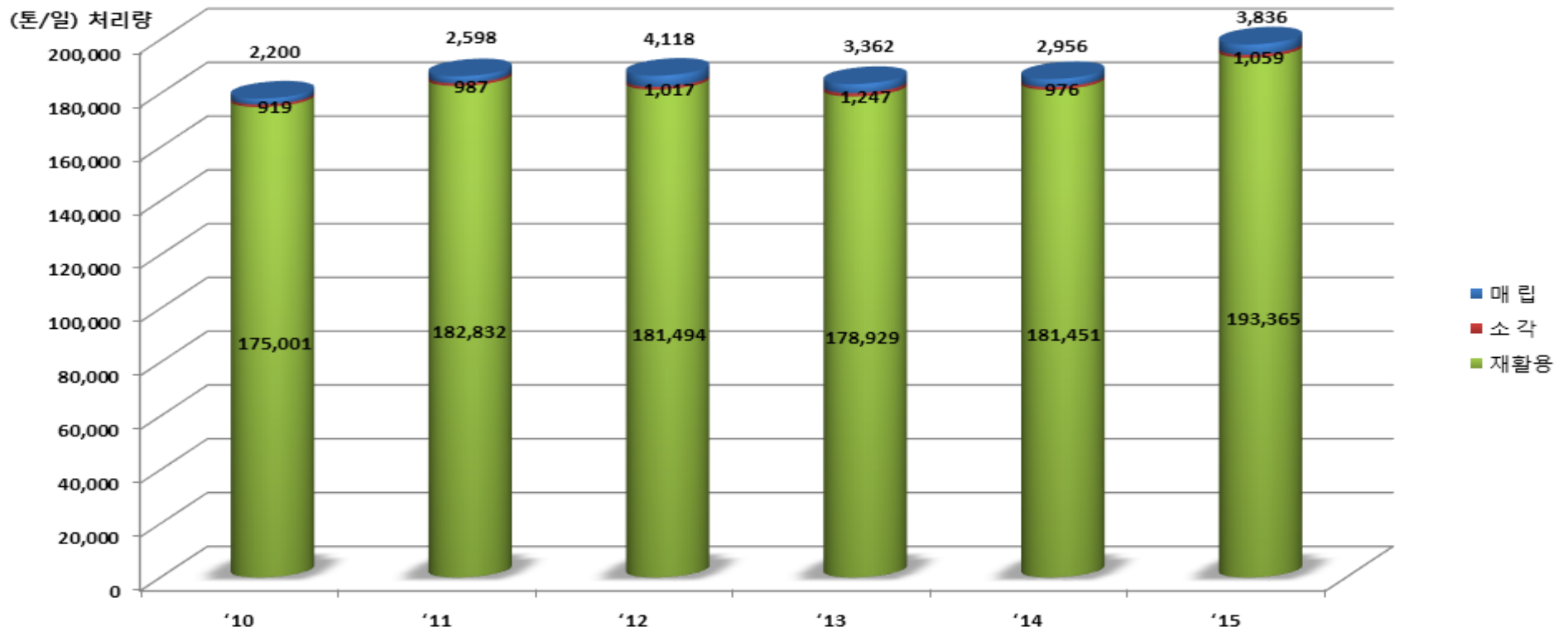
- 사업장생활계폐기물: 가정생활폐기물과 동일한 절차
- 사업장배출시설계폐기물: 배출시설 특성 별 처리공정에 따라 재활용·소각·매립
- 건설폐기물: 성상분리 후 주로 건설재료(콘크리트, 성토·복토재, 도로기층재, 뒷채움재 등)로 재활용
- 지정폐기물: 성상에 따라 처리하여 재활용·소각 후 매립 또는 지정폐기물 매립지에 매립

일반폐기물 처리현황



e-나라지표, 2017

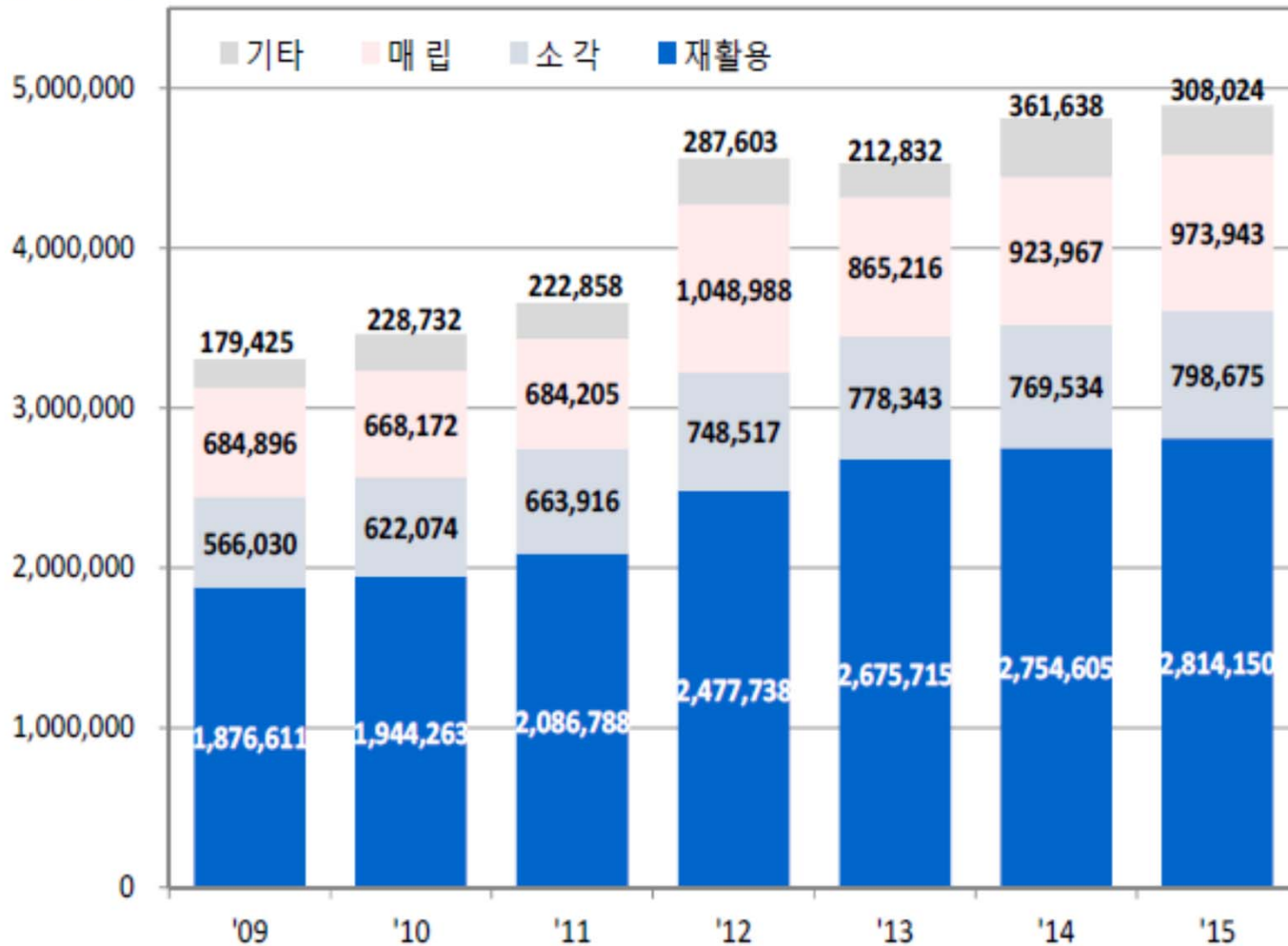
건설폐기물 처리현황



환경부, 전국 폐기물 발생 및 처리 현황(2015년도), 2016

지정폐기물 처리현황

(단위:톤/년)



환경부, 지정폐기물 발생 및 처리 현황(2015년도), 2016

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
- Reduce > Reuse > Recycle >>> Disposal

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
- Process control
 - Appropriate aeration required: may require “bulking agents” (ex: sawdust, straw, wood chips, etc.)
 - Temperature rises during composting; temp. inside the pile should go up sufficiently high ($\sim 55^{\circ}\text{C}$) in the middle of the composting for rapid process & destroying weed seeds, insect larvae, harmful bacteria, etc.



Composting

- 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: CO₂ and H₂O (and some SO₂)

Incineration (combustion)

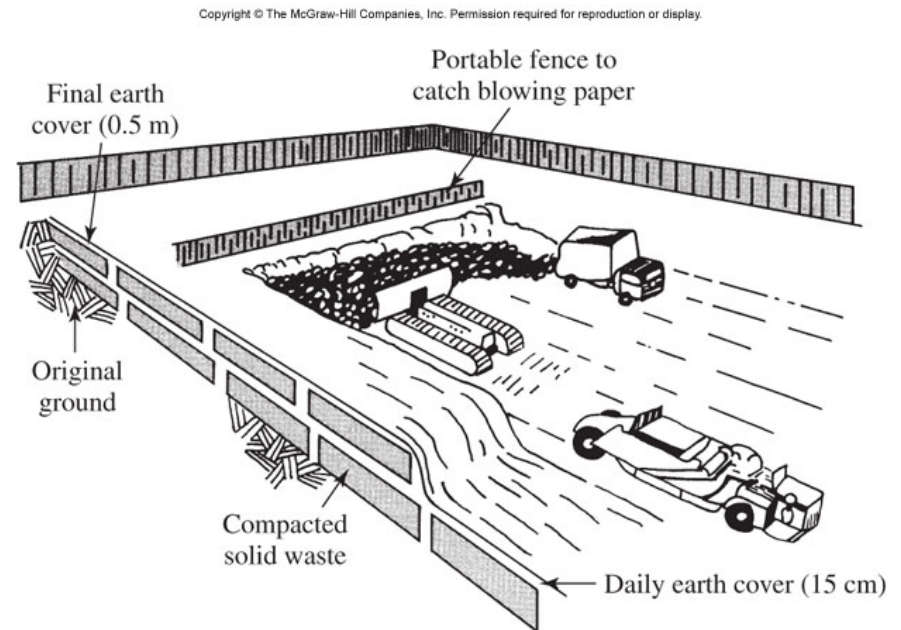
- Advantages
 - Can minimize the solid waste generation → save landfill space (good when land use is restricted)
 - Can recover heat (energy) from waste if the waste has a relatively high heating value
- Disadvantages
 - Requires additional energy input if wastes have low heating value
 - Health and 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

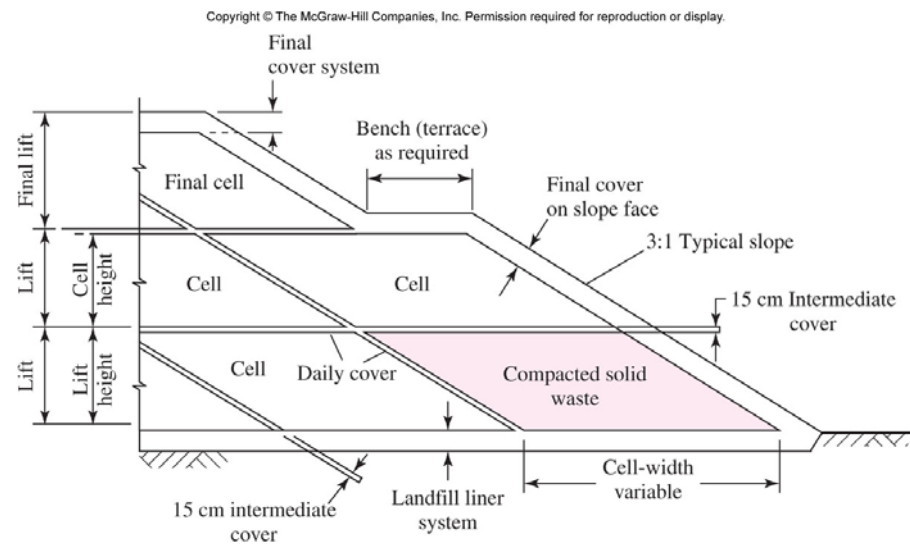
Operation of sanitary landfills

- 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)



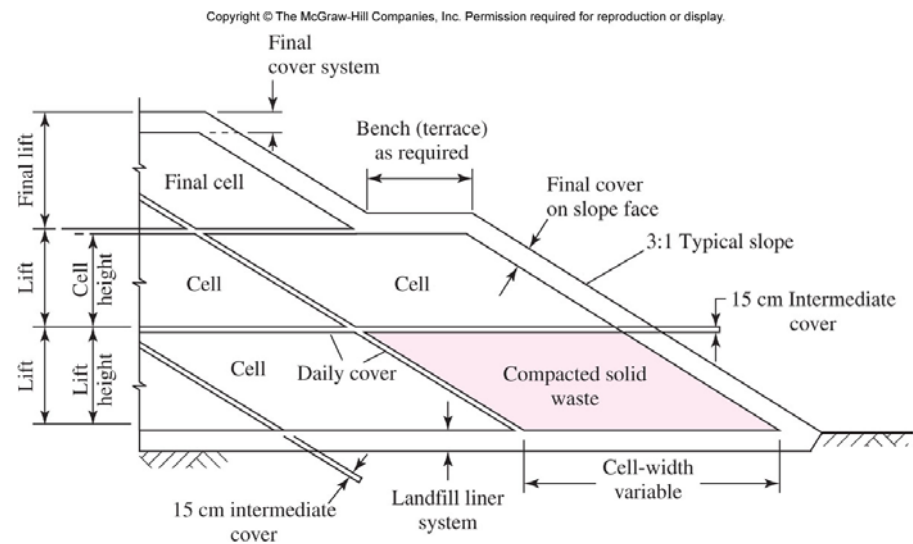
Operation of sanitary landfills

- 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

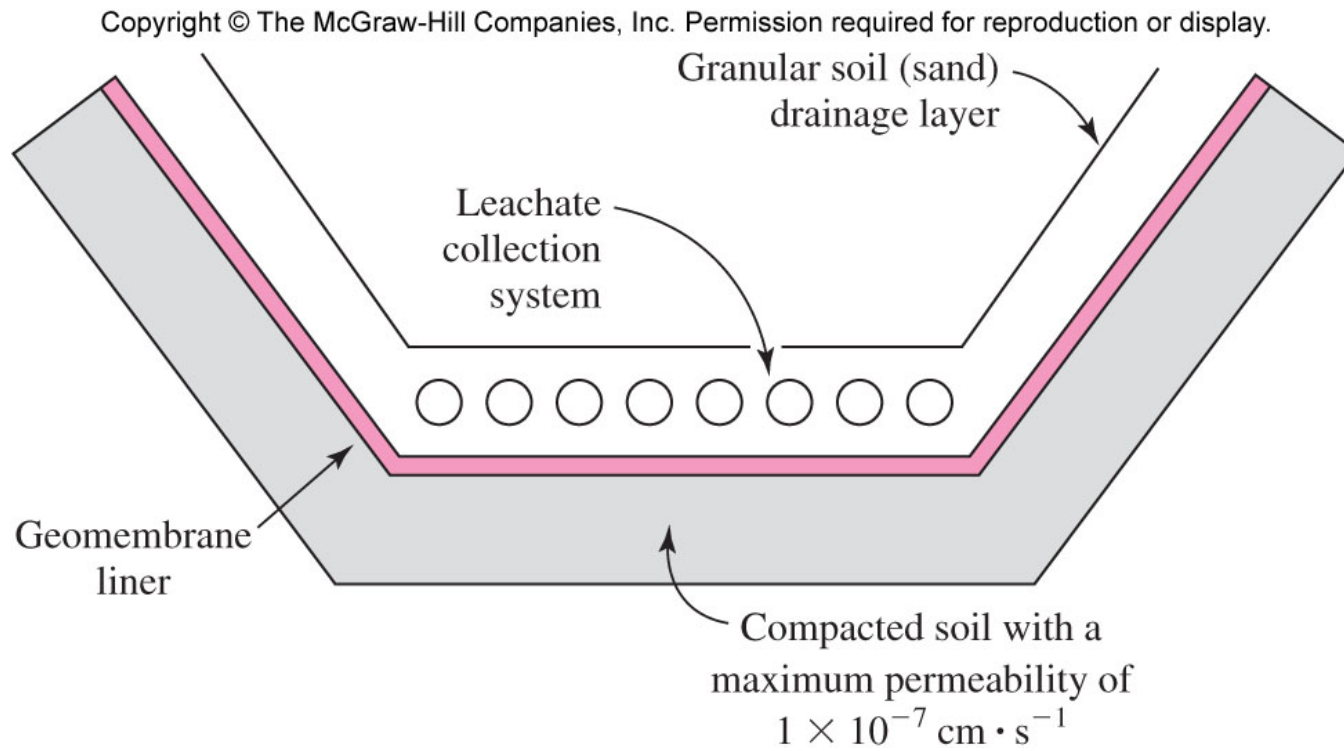
- Leachate is the liquid that passes through the landfill, extracting dissolved and suspended matter from the landfill.
- The liquid enters the landfill from rainfall, surface drainage, groundwater or is present or produced within the landfill.
- The leachate usually has a high BOD and COD, ammonia, 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

폐기물관리법, 시행령, 시행규칙

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