Solid and Hazardous Waste

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Reference: Chapter 17. Solid and Hazardous Waste. (Rodenbeck SE, Falk H) In: Frumkin's textbook, 3rd Ed.

Key concepts

- Waste is an important by-product of human activities. It can be divided into several categories, including solid waste, hazardous waste, and specialized waste, such as medical waste.
- The amount and type of waste and the management methods used vary with social and economic situations.
- Each kind of waste may have potential effects on human health.
- Various laws and policies govern the management of waste.
- The preferred approach to waste is to minimize waste generation (hopefully zero-emission)
- Waste can be managed in a variety of ways, such as incineration and landfilling. Each potential health consequences, and each must be carried out in ways that maximally protect health and environment.

What is waste?

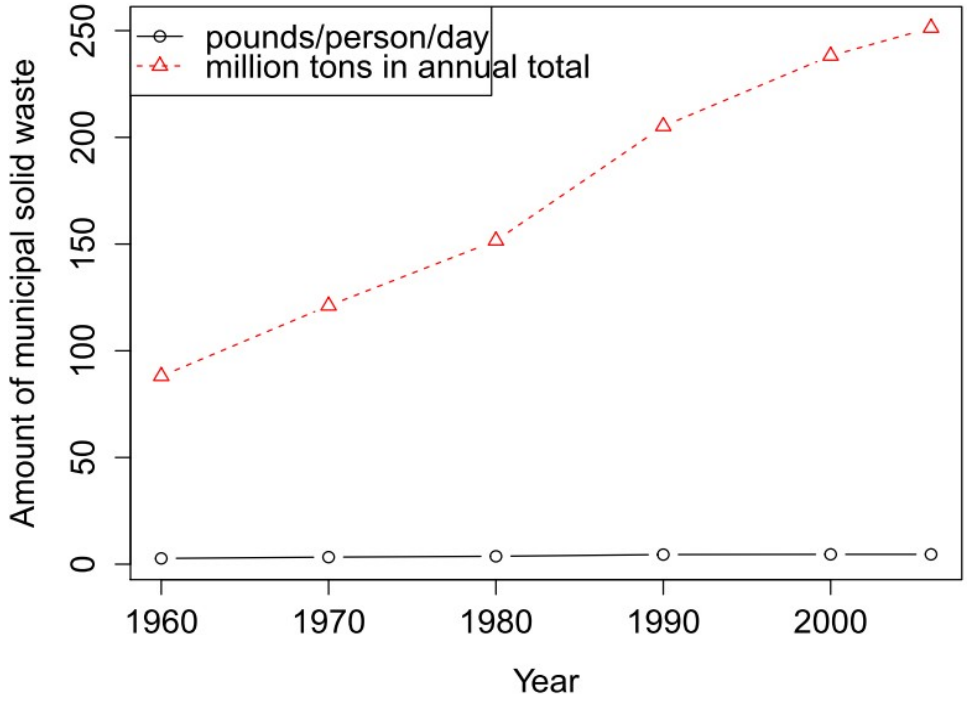
- Difficult to define. There were long history of controversial discussion.
- In general, "Value-lost goods" accompanying human subsistence and economic activities
  - Subjective (A same thing may be waste for somebody, but valuable for others)
  - Changeable with time passing
- It's more in urban than rural, resulting in pollution
  - Raw garbage and human waste (urine and feces)
    → Source of fertilizer in rural, but solely waste in urban
  - Various materials gather into urban area
  - Various industries make various waste
  - More populated -> more human waste

Figure 17.1 Chemical Drums at Love Canal
Source: Hill, 2012.

- Urbanization/Modernization made waste increased even in rural area → Regulations by laws are required → RCRA (resource conservation and recovery act) was enacted in 1976 in USA. However, during 1970's, many hazardous waste sites appeared like Love Canal in upstate New York
- Classification of solid waste in USA: Municipal solid waste / Special waste / Hazardous waste.

Municipal solid waste

- Consists of everyday items that are commonly generated from homes. More than half of USA municipal solid waste consists of containers, packaging, nondurable goods (newspapers, magazines)
- Recent laws prohibit the yard trimmings as municipal solid waste: those are to be recycled (composted)
- USA municipal solid waste increased by 70% from 1960 to 2006.
- Historically medieval London/Paris were full of disposals. Current cities in developing countries are also full of disposals in the road-side.



Roadside waste disposals in Solomon Islands

- In rural village life, most wastes are naturally decomposed or eaten by domestic animals, so that people throw wastes anywhere.
- People are not accustomed to permanent (cannot naturally be decomposed) wastes including plastic bag, tins, etc.
- In town/city, people still dispose wastes anywhere, subsequently those wastes are accumulating on roadsides.
- J-PRISM report:
  [http://www.sprep.org/attachments/j-prism/Waste%20Characterization%20Report/Solomon/Final%20Honiara%20Waste%20Characterisation%20Report%202011.pdf]
- NPO LEAF of Nishinomiya city with J-PRISM improved the situation.
  - https://www.jica.go.jp/kansai/story/151119_02.html
- Since Feb 2017, 5 years J-PRISM II started:
  - https://www.sprep.org/j-prism-2/home

Special waste - with its own rules and regulations

- **Medical waste**: generated from health care treatment or research facilities, contacted with body fluids (thus probably infectious)
  - Soiled or blood-soaked bandages, Culture dishes, Items such as gloves, gowns, and scalpels used during surgery, Needles used to give injections/drawing blood, Tissues
- **Construction debris**: generated from construction and demolition of buildings
- **Asbestos**: extensively used in the past, but most uses in USA have been banned.
- **Mining waste**: the disposal of this leftover rubble and liquid material is regulated both by solid waste laws and regulations, by water pollution control
- **Agricultural waste**: Food production is industrialized in developed countries. Concentrated Animal Feed Operation (CAFO) can bring thousands of poultry, swine or cattle together in confined spaces, where becomes large scale source of agricultural waste as air emission and animal waste
- **Radioactive waste**: Radioactive chemicals: low-level and high-level. In USA, high-level radioactive waste is permanently deposited in Yucca Mountain, Nevada (but most is stored temporarily in spent fuel pools and in dry cask storage facilities). In Japan, it is planned to be recycled (almost impossible).
- **Sewage sludge**: Before waste water is discharged, it is treated at sewage farm: One of main by-product is sewage sludge, partly disinfected to be a compost.
- **Electronic waste (e-waste)**: Unwanted, obsolete, unusable electronic equipment such as computers, televisions, VCRs, DVD players, cell phones.
  - Heavy metals, Rare metals, Brominated flame retardants
  - Reuse, recycle and proper dispose are important. Partly **exported to developing countries** as the resources for reuse and recycle, but sometimes not properly treated, **illegally dumped**.
  - **https://www.pbs.org/frontlineworld/stories/ghana804/video/video_index.html**
  - **https://i.unu.edu/media/ias.unu.edu-en/project/2238/E-waste-Guidelines_Partnership_2015.pdf**
  - **https://ewastemonitor.info/ (https://ewastemonitor.info/gem-2020/)**

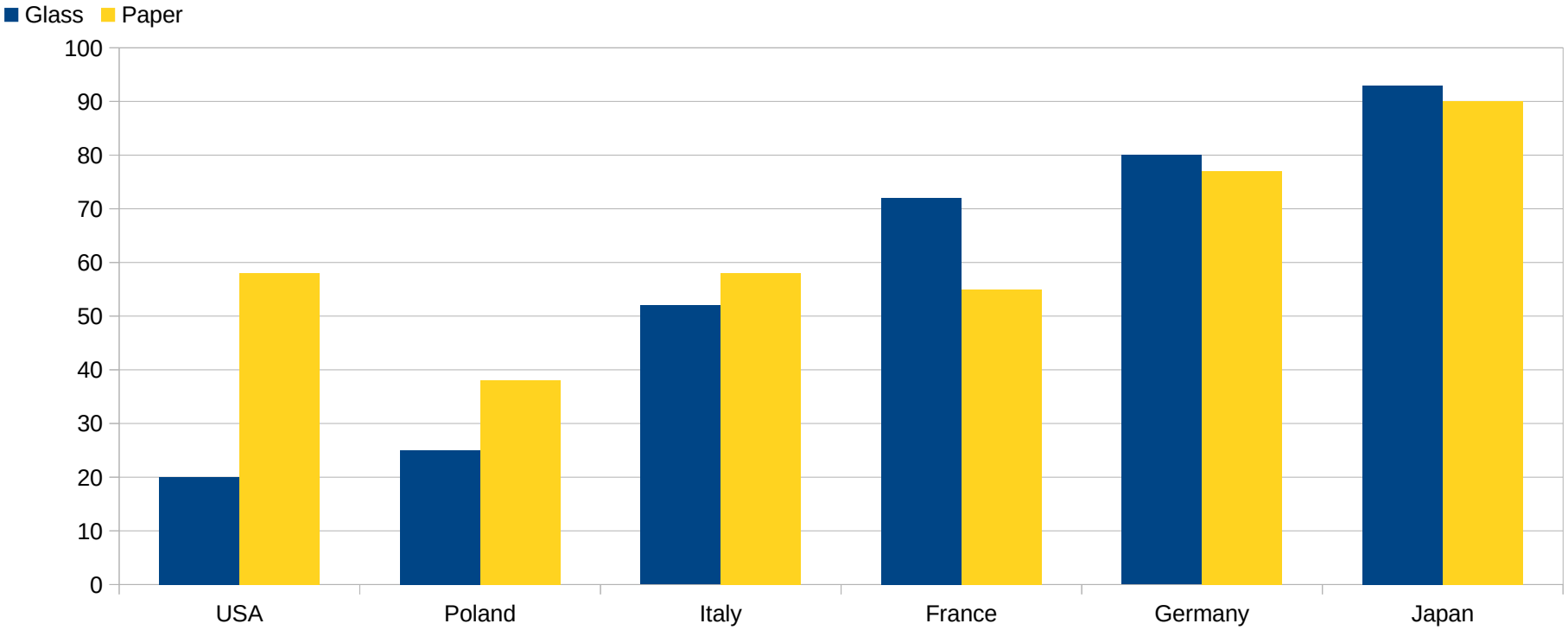
Hazardous waste

- Simply defined as waste with properties that make it capable of harming human health or the environment.
  - For regulatory purpose, this definition is insufficient.
  - In USA, Environmental Protection Agency (EPA) developed specific criteria to define hazardous waste.
    - Approx. 500 specific industrial waste
    - Standardized test criteria to determine a waste's ignitability, corrosiveness, reactivity, toxicity.
  - In 2005, approx. 38 million tons of hazardous waste was generated in USA. Highest in the world.

How to prevent waste problem

- Primary prevention of waste
  - Reduce, reuse and recycle: 3R strategy
  - Recycle of municipal solid waste has steadily increased in the USA, approx. 32.5% of waste is recycled. Other industrialized nations tend to have a higher rate of recycling.

Zeller T: Recycling: The big picture. *National Geographic*, Jan 2008, 82-87



3R strategy in Japan

[http://www.meti.go.jp/policy/recycle/main/english/index.html]
[http://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2010-eng.pdf]

- (In 1971, Waste management and public cleansing law put into force. However, rapid economic growth continued, and thus people simply believed infinite growth.)
- In 1980, so-called "oil-shock" attacked Japan.
  → People realized the risk of resource shortage.
- In 1991, the law for the promotion of utilization of recycled resources put into force.
- In 2000, containers and packaging recycling law (amended in 2006) put into force.
- In 2001, many laws for recycling put into force.← 3R concept becomes popular
  - The fundamental law for establishing a Sound Material-Cycle Society
  - Law for promotion of effective utilization of resources
  - Home appliance recycling law
  - Food recycling law (amended in June 2007)
  - Green purchasing law
- In 2002, construction waste recycling law put into force.
- In 2005, End-of-life vehicle recycling law put into force.

Actual waste management systems vary by municipalities

- Kobe City, Hyogo Prefecture
  - Classification into 6 categories, 5 categories are regularly collected
  - http://www.city.kobe.lg.jp/life/recycle/waketon/img/english.pdf
  - [cans, bottles, PET], [container plastics and trays], [*oversized garbage*], [non-burnable garbage], [gas cartridges, spray cans], [burnable garbage]
- Kamikatsu Town, Tokushima Prefecture
  - Classification into 34 categories, bring by oneself on any day
  - Aiming “Zero Waste”, recycling everything as possible
  - https://www.soumu.go.jp/main_content/000336011.pdf
  - https://www.japan.go.jp/kizuna/2021/04/zero-waste_world.html
  - http://www.clair.or.jp/e/bestpractice/docs/2017kamikatsu_e_r.pdf
  - https://www.citylab.com/equity/2015/12/let-this-japanese-town-show-you-how-zero-waste-is-done/419706/
    - https://www.youtube.com/watch?v=eym10GGidQU
  - https://www.abc.net.au/news/2018-05-20/kamikatsu-the-japanese-town-with-45-different-recycling-bins/9776560

Waste treatment/disposal

- <The purpose of treatment> **Reducing sizes** as much as possible and **detoxification**
- History of Waste Management in Japan
  https://www.env.go.jp/content/900453392.pdf
- Current treatment technologies in Japan
  https://www.env.go.jp/content/900453393.pdf
- The (final) disposals are
  - Sanitary landfill: an adequate area to provide waste disposal capacity within a reasonable time period, an adequate elevation/separation to regional ground water, available soil, adequate buffer from surrounding populations: Protecting ground water from leachate is important.
  - Incineration
    https://www.youtube.com/watch?v=Bb-RoAWv3ro
  - Deep well injection (as one of underground injection control, Class I wells are used for waste disposal)
    https://www.epa.gov/uic
  - Other technologies
    Supercritical water oxidation, molten metals and molten salt oxidation, waste-specific biological treatment, thermal desorption, in situ and extractive remediation, and so on.

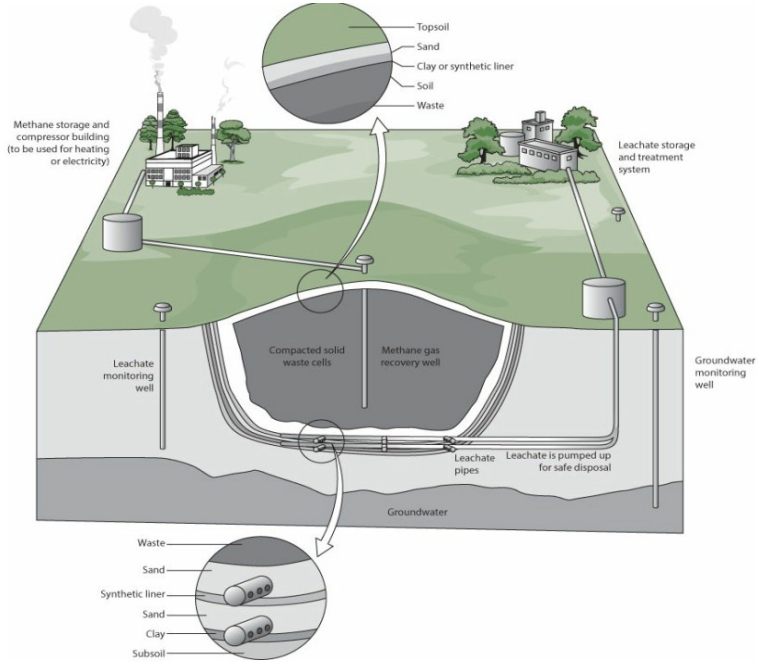


Figure 17.7 Generalized Depiction of a State-of-the-Art Sanitary Landfill

(Cited from Frumkin's text)

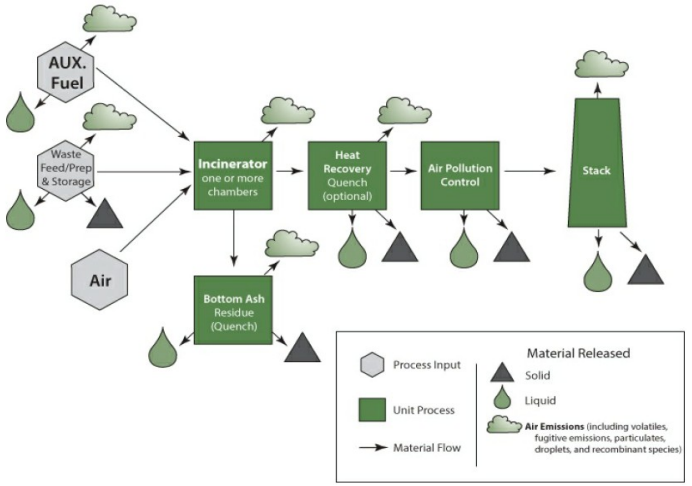
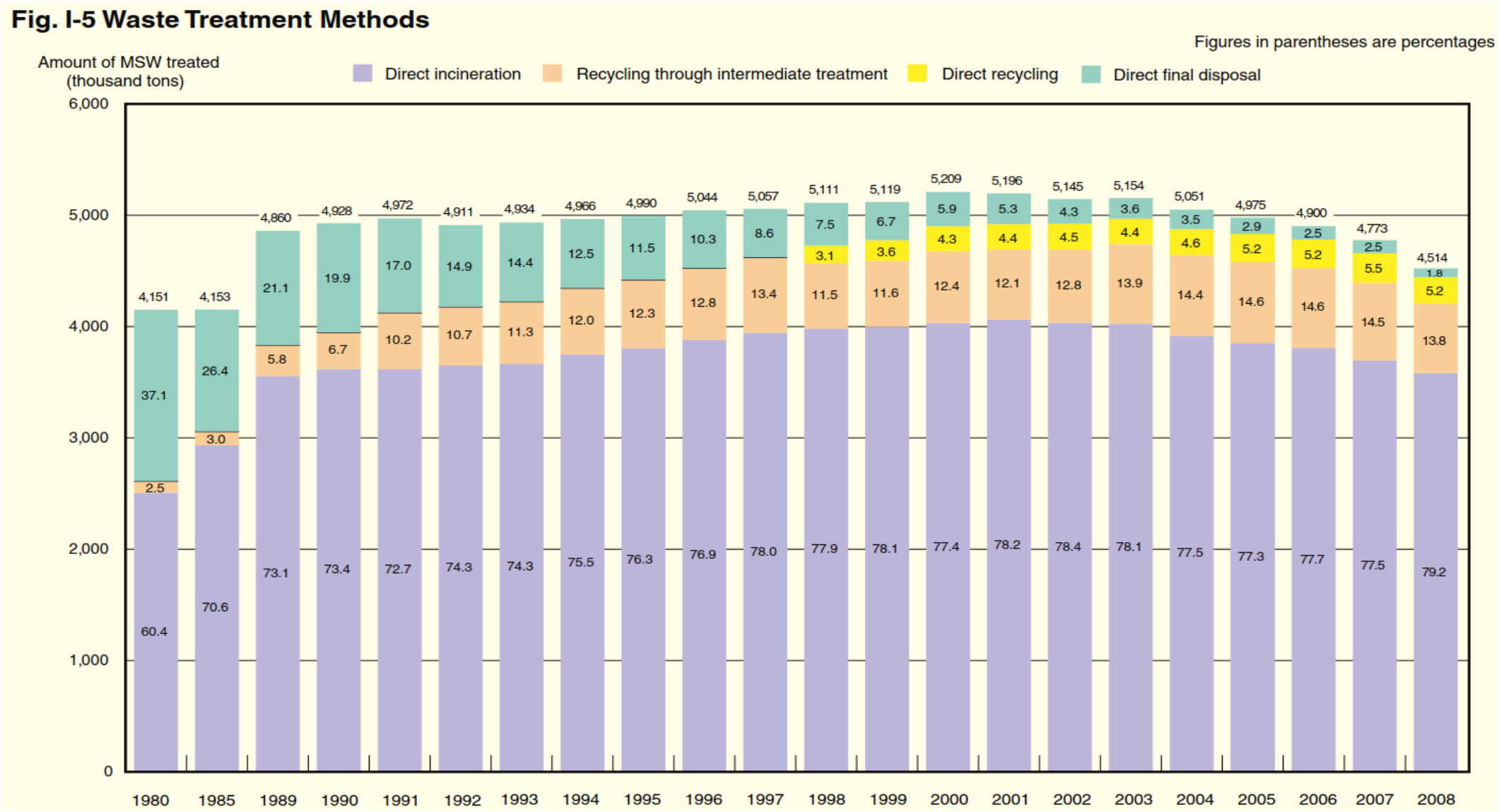


Figure 17.8 Generalized Diagram of Incineration Material and Process Flow

Municipal solid waste treatment in Japan

[https://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2010-eng.pdf]
linked from [https://www-cycle.nies.go.jp/eng/column/about.html]

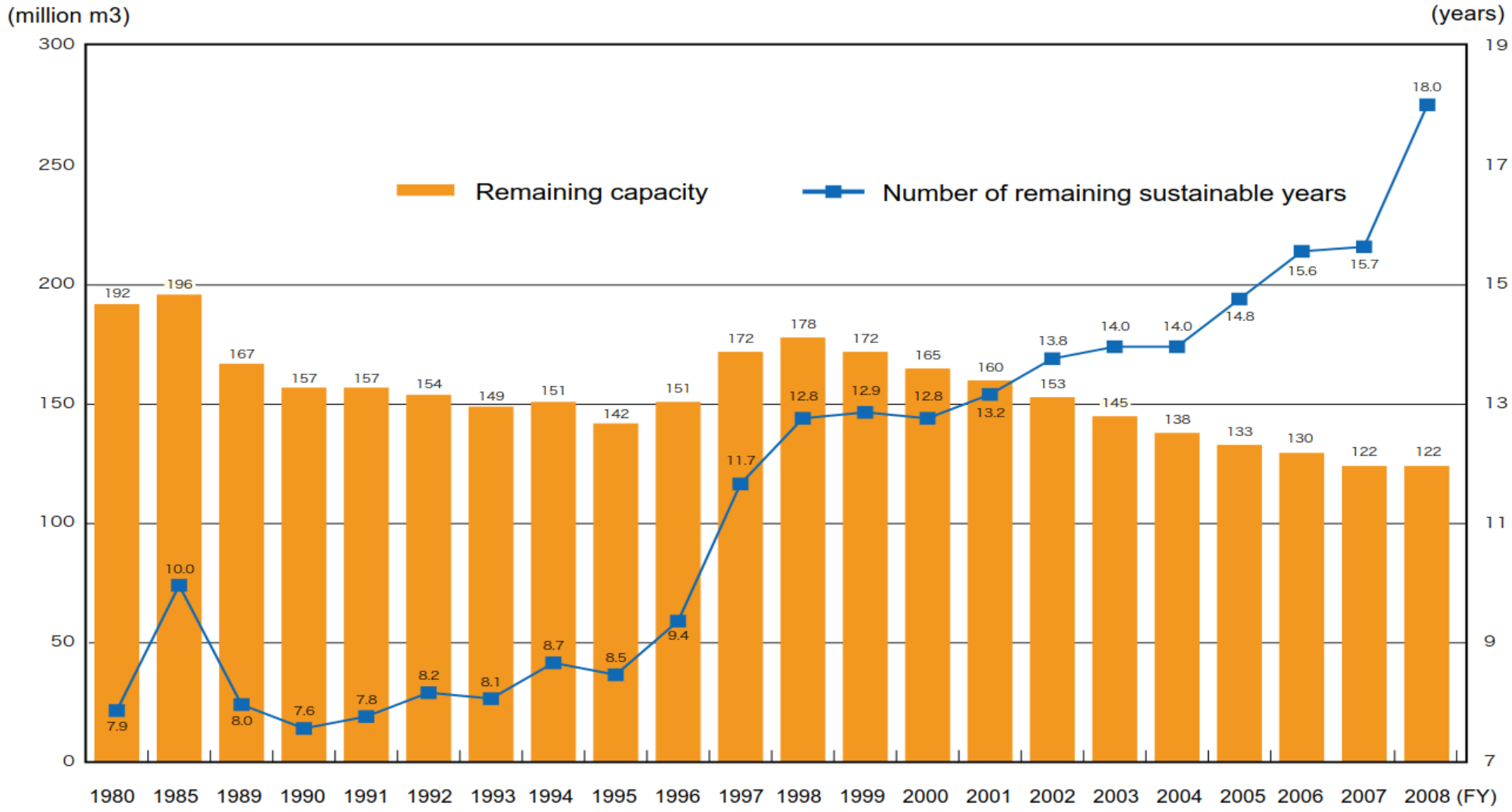
Fig. I-5 Waste Treatment Methods



Remaining capacity of final disposals of MSW in Japan

[https://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2010-eng.pdf]

Fig. I-7 Remaining Capacity and Number of Remaining Sustainable Years of Final Disposal Sites for MSW



Final disposal site

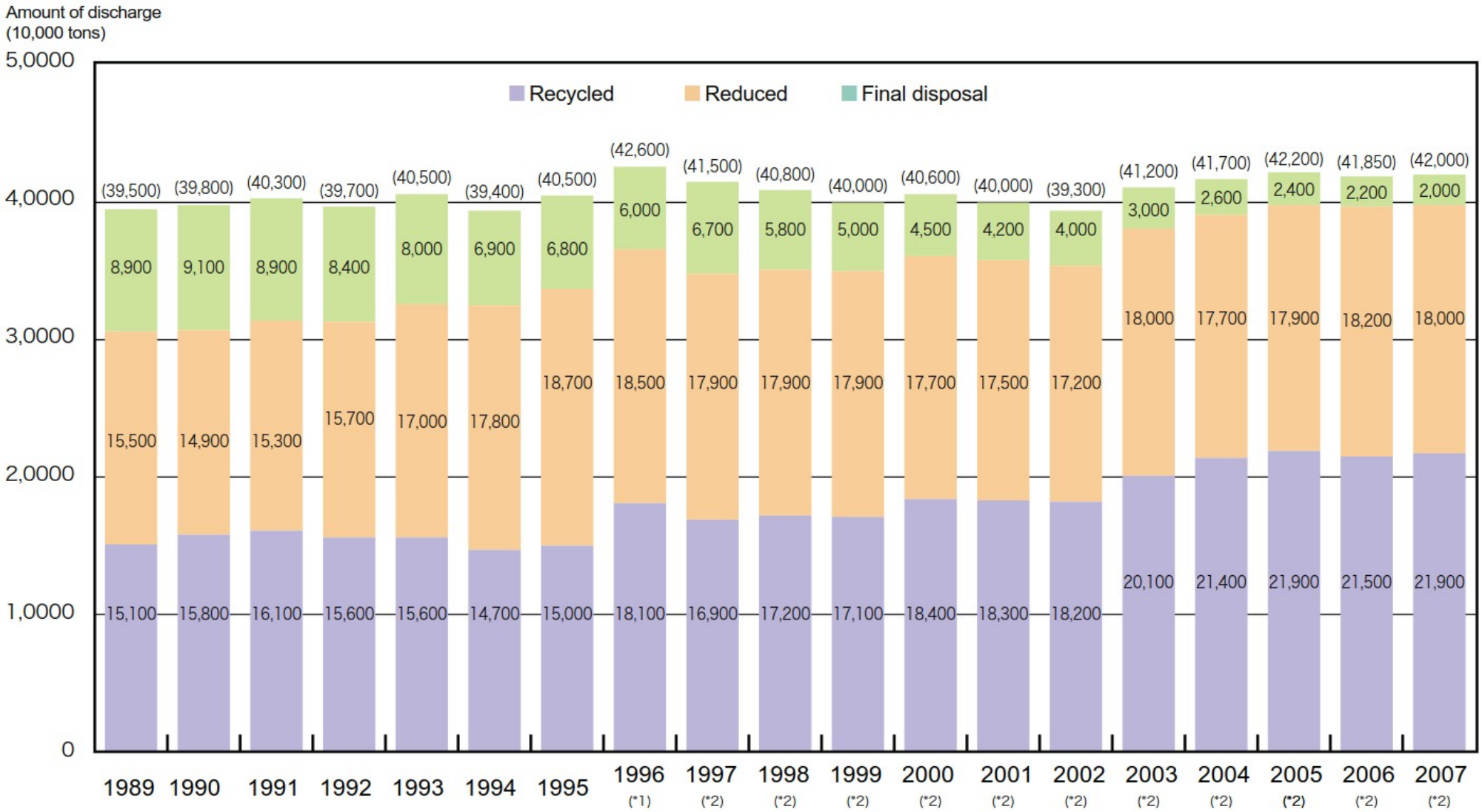
[https://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2010-eng.pdf]

Final landfill/Facility for exudated water treatment

Industrial waste discharge in Japan

[https://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2010-eng.pdf]

Fig. I-8 Industrial Waste Discharge



Remaining capacity of final diposals for industrial waste in Japan

[https://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/handbook2010-eng.pdf]

Fig. I-11 Remaining Capacity and Number of Remaining Sustainable Years of Final Disposal Sites for Industrial Waste

Health concerns

- See also,
  - Grant K et al. (2013) Health consequences of exposure to e-waste: a systematic review. *Lancet Global Health*, https://doi.org/10.1016/S2214-109X(13)70101-3
  - Parvez SM et al. (2021) Health consequences of exposure to e-waste: an updated systematic review. *Lancet Planetary Health*, https://doi.org/10.1016/S2542-5196(21)00263-1
  - Ankit et al. (2021) Electronic waste and their leachates impact on human health and environment: Global ecological threat and management. *Environmental Technology & Innovation*, https://doi.org/10.1016/j.eti.2021.102049
- At least five kinds of health hazards may be generated by solid and hazardous wastes
  - Infectious disease risks from poorly managed solid waste
  - Contamination of drinking water and soil by biological, chemical and mining waste
  - Gas migration and leachate discharges from landfills
  - Emissions of air pollutants from incinerations
  - Contamination of food by waste chemicals that escape into the environment

PFAS in waste

- Stoiber T et al. (2020) Disposal of products and materials containing per- and polyfluoroalkyl substances (PFAS): A cyclical problem, Chemosphere, 2020, 127659. https://doi.org/10.1016/j.chemosphere.2020.127659
- Wisconsin Department of Natural Resources > Waste containing PFAS https://dnr.wisconsin.gov/topic/pfas/waste
- Kibichuo town incident

  https://www.militarypoisons.org/latest-news/kibichuo-japans-giant-tea-bags
  https://www.japantimes.co.jp/news/2024/11/25/japan/pfas-blood-tests-okayama/
- Regulations
  - USEPA [https://www.epa.gov/pfas]
    - Strategic Roadmap 2021-2024 https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024
    - Interim Guidance (2020) https://www.epa.gov/system/files/documents/2021-11/epa-hq-olem-2020-0527-0002_content.pdf
  - Japan's Ministry of Environment https://www.env.go.jp/en/focus/docs/files/201304-89.pdf
  - South Australia https://www.epa.sa.gov.au/files/14469_guide_pfas_landfill_disposal.pdf