Chapter 21:
Solid and Hazardous Waste

APES 2013

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Electronic Waste

- Also known as e-waste
- Fastest growing solid waste problem
- Each year, Americans throw out 155 million cell phones, 48 million computers, as well as millions of TVs, iPods, and other electronic products
- Most end up in landfills or incinerators even though these materials include high-quality plastics, aluminum, copper, nickel, platinum, silver, and gold.
- Source of hazardous pollutants like PVC, flame retardants, lead, and mercury which contaminate air, surface water, groundwater, and soil
- 70% of e-waste is shipped to China. The rest goes to India and poor African countries

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Basics of Waste

- In nature, there is no waste. The waste of organisms becomes the nutrients for others.
- Humans produce huge amounts of waste that go unused and pollute the environment
- We will always produce waste (law of conservation of matter), but the amount can be reduced.

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Waste

- Solid Waste - any unwanted or discarded material that is not a liquid or gas
- Industrial solid waste - produced by mines, agriculture, and industries
- Municipal solid waste (MSW) - solid waste produced by homes and workplaces
  - In developed counties, MSW is either put in landfills or burned in incinerators.
  - In developing countries, it ends up in open dumps.
- Hazardous waste (toxic waste) - threatens human health or the environment because it is poisonous, dangerously chemically reactive, corrosive, or flammable (organic compounds and toxic heavy metals)

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Nuclear Waste

- Produced by nuclear power plants and nuclear weapons facilities
- Must be stored for 10,000 to 240,000 years

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Fig. 21-2

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United States Solid Waste

- U.S. leads the world in producing solid waste
  - 4.6% of the world's population but produces about 33% of solid waste
  - 98.5% of U.S. waste is industrial from mining (76%), agriculture (13%), and industry (9.5%)
  - For every one pound of electronics produced about 8,000 pounds of waste were produced

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U.S. MSW

- 1.5% of total waste
  - Paper and cardboard (37%), yard waste (12%), food waste (11%), plastics (11%), metals (8%)
- Yearly MSW could fill bumper-to-bumper convoy of trucks that circles the earth almost eight times

Fig. 21-4

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New York City

- Per person trash output has actually gone down.
- 1999 NYC passed a mandatory recycling law
  - Had a law like this from 1896-1914
- 1st major city to run out of landfill space
- Since then it has been transporting its MSW to New Jersey and Pennsylvania

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Dealing with Waste

- Waste management - reduce the environmental impact of MSW without reducing the amount of waste produced
- Waste reduction - much less waste and pollution are produced
- Integrated waste management - variety of strategies for both waste reduction and waste management

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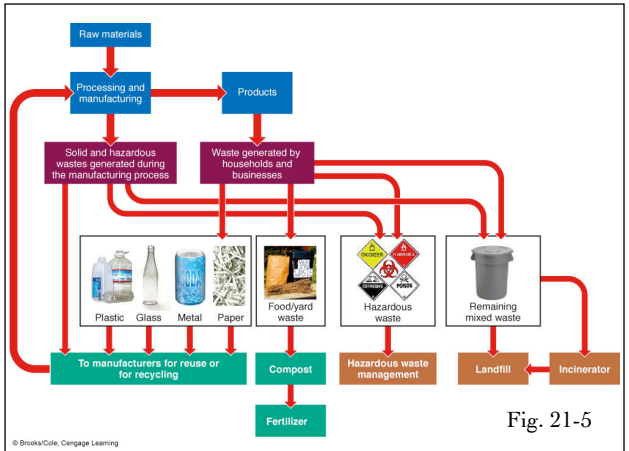

Fig. 21-5

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Integrated Waste Management

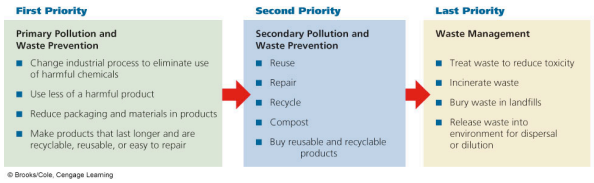

Fig. 21-6

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Reduce, Reuse, and Recycle

- Strategies:
  - Redesign manufacturing processes and products to use less material and energy
  - Redesign manufacturing processes to produce less waste and pollution
  - Develop products that are easier to repair, reuse, remanufacture, compost, or recycle
  - Eliminate or reduce unnecessary packaging
  - Use fee-per-bag collection system
  - Cradle to grave responsibility laws (think cradle to cradle)
  - Restructure urban transportation systems

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WHAT CAN YOU DO?

Solid Waste

- Follow the three Rs of resource use: Reduce, Reuse, and Recycle
- Ask yourself whether you really need a particular item, and refuse packaging where possible
- Rent, borrow, or barter goods and services when you can, buy secondhand, and donate or sell unused items
- Buy things that are reusable, recyclable, or compostable, and be sure to reuse, recycle, and compost them
- Avoid disposables, and do not use throwaway paper and plastic plates, cups, and eating utensils, and other disposable items when reusable or refillable versions are available
- Use e-mail or text-messaging in place of conventional paper mail
- Read newspapers and magazines online
- Buy products in bulk or concentrated form whenever possible

Fig. 21-7

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WHAT CAN YOU DO?

Reuse

- Buy beverages in refillable glass containers instead of cans or throwaway bottles
- Use reusable plastic or metal lunchboxes
- Carry sandwiches and store food in the refrigerator in reusable containers instead of wrapping them in aluminum foil or plastic wrap
- Use rechargeable batteries and recycle them when their useful life is over
- Carry groceries and other items in a reusable basket, a canvas or string bag, or a small cart
- Use reusable sponges and washable cloth napkins, dish towels, and handkerchiefs instead of throwaway paper ones
- Buy used furniture, computers, cars, and other items instead of buying new
- Give away or sell items you no longer use

Fig. 21-9

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Types of Recycling

- Primary (closed-loop) - materials recycled into new products of the same type (ex. used aluminum cans into new aluminum cans)
- Secondary - waste materials converted into different products (ex. tires converted into rubberized road surfacing, newspapers into insulation)
- Materials-recovery facilities - send mixed wastes to a factory that sorts out the recyclable materials (more expensive, more pollutants produced)
- Source separation - consumers separate out materials (costs less, less pollution)
- Pay-as-you-throw (Fee-per-bag) - charges by amount of waste thrown away but does not charge for pick-up of recycled material

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Composting

- Mimics nature's recycling of nutrients
- Allows decomposer bacteria to recycle yard trimmings, food scraps, and other organic wastes
- Resulting materials can be added to soil to supply plants with nutrients
- Large-scale composting - located carefully (odors monitored)

Fig. 21-10

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Recycling Paper

- In most countries paper is the dominant material of MSW
- Paper industry is the fifth most polluting and energy consuming industry in the world (3rd in U.S. and Canada)
- Paper is easy to recycle
  - Recycled paper uses 64% less energy, produces 35% less waste, and 74% less air pollution
  - U.S. recycles 56% of its paper (Denmark recycles 97%)
    - Even with our recycling rate, we still throw away more paper per year than is used in China.

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Recycling Plastics

- Currently only 4% of plastic (by weight) is recycled in the U.S.
- Reasons for lack of recycling:
  - Many plastics are difficult to isolate with different types in different layers
  - Individual plastic items do not yield much resin
  - Inflation-adjusted price of oil is low which incentivizes using new (virgin) plastics

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Fig. 21-12

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Burning Solid Waste

- MSW is burned to heat water and produce electricity
- Reduce amount of solid waste by 90%
- Release many harmful chemicals into the air (particulates, carbon monoxide, toxic metals)
- Add carbon dioxide to the atmosphere
- Discourages reuse and recycling because large volumes are required to make it economically feasible

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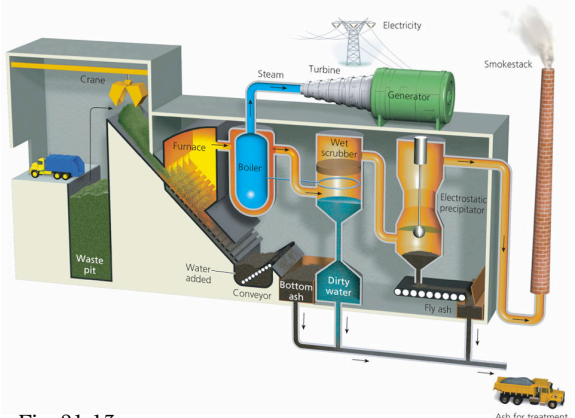

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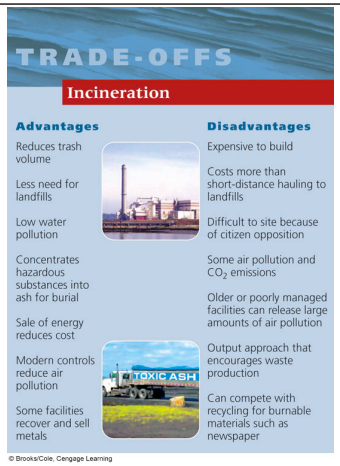

Fig. 21-14

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Burying Waste

- 54% of waste (by weight) is buried in landfills
- Two types:
  - Open dumps - fields or holes in the ground where garbage is dumped (rare in developed countries)
  - Sanitary landfills - solid waste is spread into thin layers compacted and covered in clay or plastic foam (keeps material dry and prevents leakage)

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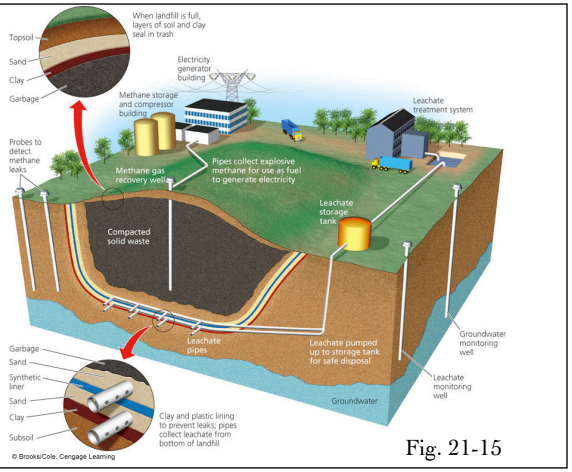

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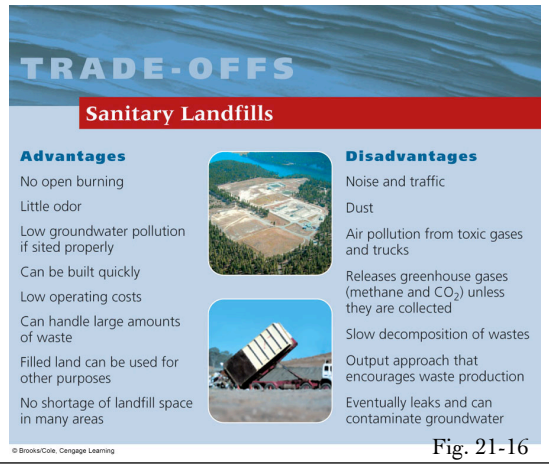

Fig. 21-16

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Fig. 21-17

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Detoxifying Hazardous Waste

- Physical methods - using charcoal or resins to filter out harmful solids and distilling liquid mixtures to separate out harmful chemicals
- Chemical methods - convert hazardous chemicals to harmless or less harmful ones (ex. cyclodextrin to remove toxic materials like solvents and pesticides from contaminated soil and groundwater)
  - After it makes its way through the ground or water, it can be pumped out , cleaned of the hazardous chemicals and reused.

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Detoxifying Hazardous Waste

- Nanomagnets - magnetic nanoparticles coated with certain compounds that remove various pollutants from water (ex. chitosan - made from the exoskeletons of shrimp and crabs used to remove oil from contaminated water)

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Biological Detoxification Methods

- Bioremediation - bacteria and enzymes destroy toxic or hazardous substances or convert them to harmless compounds
- Phytoremediation - using plants to absorb, filter, and remove contaminants from polluted soil and water

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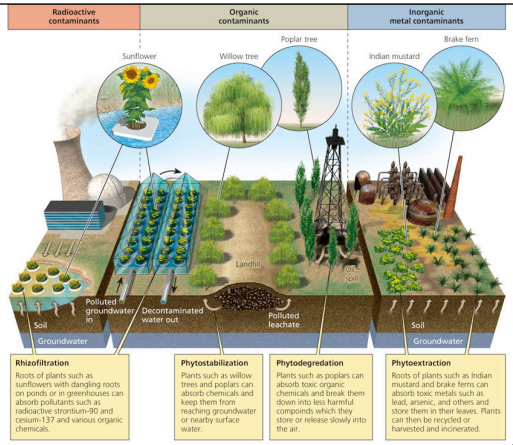

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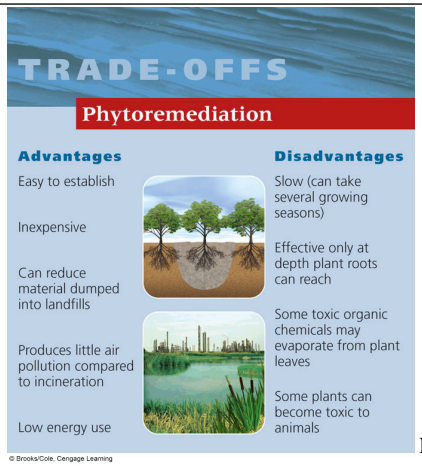

Fig. 21-19

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Plasma Arc Torch

- Incinerate hazardous waste at very high temperatures by passing electric current through a gas to create plasma (ionized gas)
- Converts hazardous waste into ions and atoms of hydrogen and carbon monoxide
- This fuel can be used to make fuels like hydrogen gas and methane

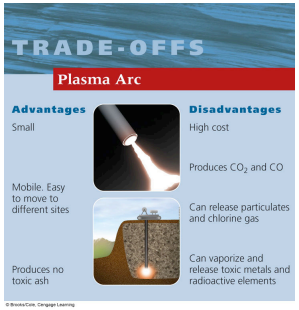

Fig. 21-20

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Hazardous Waste Storage

- Burial or land storage should only be used as a third resort, even though it is the most widely used method.
- Deep-well disposal - liquid hazardous waste is pumped through a pipe into dry, porous rock formations far beneath aquifers
- Surface impoundments - ponds, pits, or lagoons with liners and hazardous wastes are stored
- Secure hazardous waste landfills - waste put into drums or other containers and buried in monitored sites

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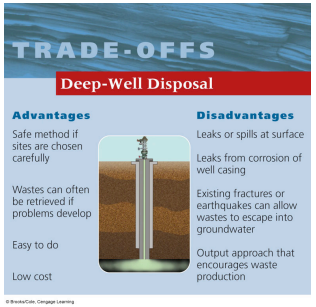
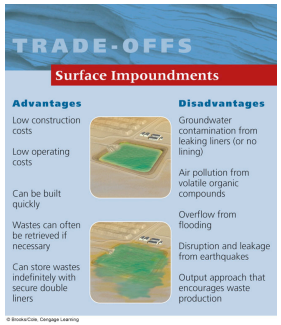


Fig. 21-21

Fig. 21-23



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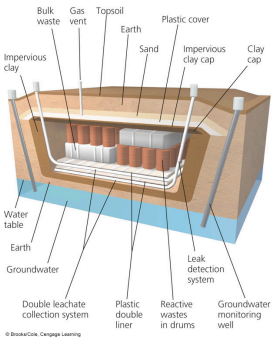
Secure Hazardous Waste Landfill



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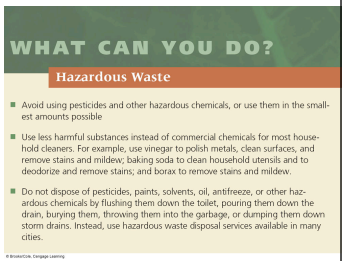

Fig. 21-25

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Hazardous Waste Regulation

- Resource Conservation and Recovery Act (RCRA) - 5% of hazardous waste are regulated by this. EPA sets standards for management of several hazardous wastes. Those awarded permits must use cradle-to-grave systems.
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - Also known as Superfund program. Identifies sites where hazardous wastes have contaminated the environment and clean them up on a priority basis
  - 2008 - 1,240 sites on the list (It is estimated there should be closer to 10,000 sites on the list. The cost to clean up all sites would exceed $1.7 trillion.)
  - Since 1980, 321 have been cleaned up enough to be removed from the list.

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Toxic Release Inventory

- In 1984, Congress amended the Superfund Act to give citizens the right to know what toxic chemicals are being stored or released in their community (www.epa.gov/tri)
- Superfund law has made illegal dumping sites almost non-existent, made polluters pay for cleanup, made polluters reduce production of hazardous waste for fear of liability, and made recycling and reuse more prevalent.
- In 1995, Congress refused to renew a tax on oil and chemical companies that funds the Superfund law so now taxpayers foot the bill for cleaning up sites. (This has slowed the pace of cleanup.)

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Brownfields

- Abandoned industrial and commercial sites contaminated with hazardous wastes
- Cleaned up and reborn as parks, nature reserves, athletic fields, eco-industrial parks, and neighborhoods
- By 2008, 42,000 brownfields have been redeveloped

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Environmental Justice

- Ideal whereby every person is entitled to protection from environmental hazards regardless of race, gender, age, national origin, income, social class, or political factor
- Disproportionate numbers of hazardous sites are in areas where minorities are present and where poor people live.