Solid and Hazardous Waste

Chapter 21

21-1 What Are Solid Waste and Hazardous Waste, and Why Are They Problems?

- ***Concept 21-1*** *Solid waste represents pollution and unnecessary waste of resources, and hazardous waste contributes to pollution, natural capital degradation, health problems, and premature deaths.*

We Throw Away Huge Amounts of Useful Things and Hazardous Materials (1)

- **Solid waste**
  - **Industrial solid**
  - **Municipal solid waste (MSW)**
  - **Hazardous, toxic, waste**
- Hazardous wastes
  - Organic compounds
  - Toxic heavy metals
  - Radioactive waste

We Throw Away Huge Amounts of Useful Things and Hazardous Materials (2)

- 80–90% of hazardous wastes produced by developed countries
- Why reduce solid wastes?
  - ¾ of the materials are an unnecessary waste of the earth's resources
  - Huge amounts of air pollution, greenhouse gases, and water pollution

What Harmful Chemicals Are in Your Home?

Natural Capital Degradation: Solid Wastes Polluting a River in Indonesia

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Solid Waste in the United States

- Leader in solid waste problem
  - What is thrown away?
- Leader in trash production, by weight, per person
- Recycling is helping

Hundreds of Millions of Discarded Tires in a Dump in Colorado, U.S.

21-2 How Should We Deal with Solid Waste?

- ***Concept 21-2*** *A sustainable approach to solid waste is first to reduce it, then to reuse or recycle it, and finally to safely dispose of what is left.*

We Can Burn or Bury Solid Waste or Produce Less of It

- **Waste Management**
- **Waste Reduction**
- **Integrated waste management**
  - Uses a variety of strategies (Fig. 21-5)

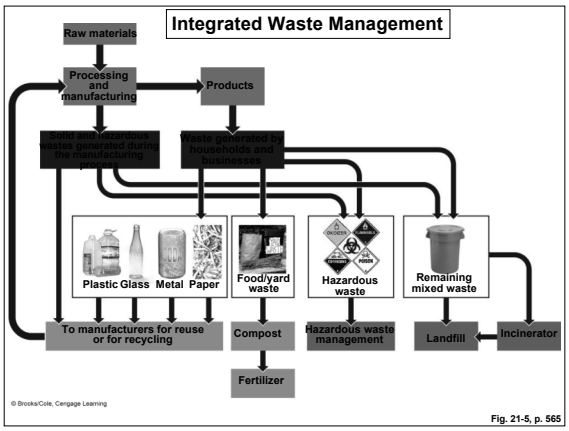


Fig. 21-5, p. 565

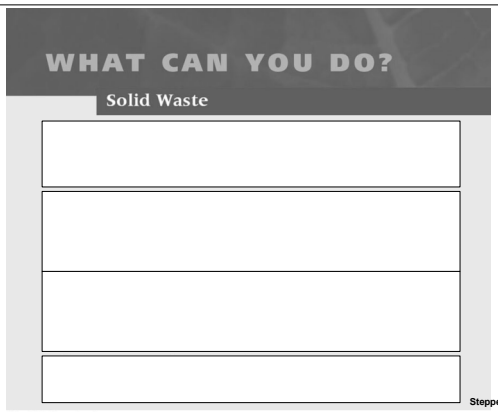
Fig. 21-6, p. 565

We Can Cut Solid Wastes by Reducing, Reusing, and Recycling (1)

- Waste reduction is based on
  - **Reduce**
  - **Reuse**
  - **Recycle**
- Seven strategies:
  (1) Redesign manufacturing processes and products to use less material and energy
  (2) Redesign manufacturing processes to produce less waste and pollution

We Can Cut Solid Wastes by Reducing, Reusing, and Recycling (2)

- Seven strategies cont…
  (3) Develop products that are easy to repair, reuse, remanufacture, compost, or recycle
  (4) Eliminate or reduce unnecessary packaging
  (5) Use fee-per-bag waste collection systems
  (6) Establish cradle-to grave responsibility
  (7) Restructure urban transportation systems



Stepped Art
Fig. 21-7, p. 566

21-3 Why Is Reusing and Recycling Materials So Important?

- ***Concept 21-3*** *Reusing items decreases the use of matter and energy resources and reduces pollution and natural capital degradation; recycling does so to a lesser degree.*

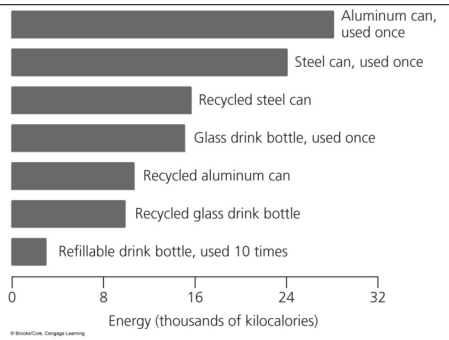
Reuse: Important Way to Reduce Solid Waste, Pollution and to Save Money

- Reuse: clean and use materials over and over
- Downside of reuse in developing countries
- Salvaging automobiles parts
- Rechargeable batteries

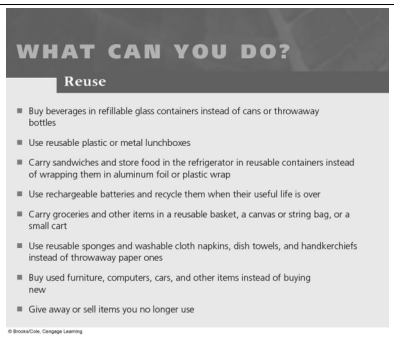
Case Study: Use of Refillable Containers

- Reuse and recycle
  - Refillable glass beverage bottles
  - Refillable soft drink bottles made of polyethylene terephthalate (PET) plastic
- Paper, plastic, or reusable cloth bags
  - Pros
  - Cons

Energy Consumption Involved with Using Different Types of 350 ml Containers



What Can You Do? Reuse



There Are Two Types of Recycling

- **Primary, closed-loop recycling**
- **Secondary recycling**

- Types of wastes that can be recycled
  - Preconsumer: internal waste
  - Postconsumer: external waste
- Do items actually get recycled?
- What are the numbers?
- Will the consumer buy recycled goods?

We Can Mix or Separate Household Solid Wastes for Recycling

- **Materials-recovery facilities (MRFs)**
- **Source separation**
  - **Pay-as-you-throw**
  - **Fee-per-bag**
- Which program is more cost effective?
- Which is friendlier to the environment?

We Can Copy Nature and Recycle Biodegradable Solid Wastes

- **Composting**
  - Individual
  - Municipal
- Benefits
- Successful program in Edmonton, Alberta, Canada

Backyard Composter Drum: Bacteria Convert Kitchen Waste into Compost

Case Study: Recycling Paper

- Production of paper versus recycled paper
  - Energy use
  - Water use
  - Pollution
- Countries that are recycling
- Replacement of chlorine-based bleaching chemicals with H_2O_2 or O_2

Case Study: Recycling Plastics

- Plastics: composed of resins
- Most containers discarded: 4% recycled
- Litter: beaches, water
  - Significance?
- Low plastic recycling rate
  - Hard to isolate one type of plastic
  - Low yields of plastic
  - Cheaper to make it new

Discarded Solid Waste Litters Beaches

Science Focus: Bioplastics

- Plastics from soybeans: not a new concept
- Key to bioplastics: catalysts
- Sources
  - Corn
  - Soy
  - Sugarcane
  - Switchgrass
  - Chicken feathers
  - Some garbage
  - CO_2 from coal-burning plant emissions
- Benefits: lighter, stronger, cheaper, and biodegradable

Recycling Has Advantages and Disadvantages

- Advantages (Fig. 21-12)
- Disadvantages (Fig. 21_12)

Fig. 21-12, p. 573

We Can Encourage Reuse and Recycling

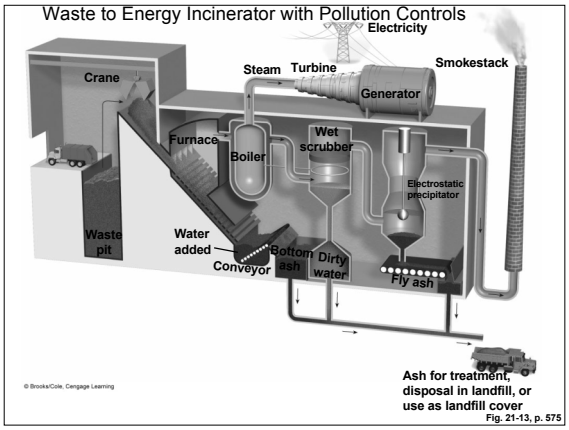
- What hinders reuse and recycling?
- Encourage reuse and recycling
  - Government
    - Increase subsidies and tax breaks for using such products
    - Decrease subsidies and tax breaks for making items from virgin resources
  - Fee-per-bag collection
  - New laws
  - Citizen pressure

21-4 The Advantages and Disadvantages of Burning or Burying Solid Waste

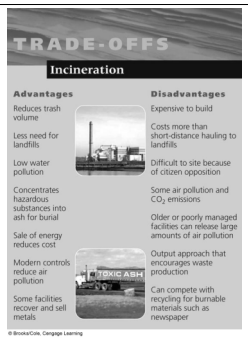
- ***Concept 21-4*** *Technologies for burning and burying solid wastes are well developed, but burning contributes to pollution and greenhouse gas emissions, and buried wastes eventually contribute to pollution and land degradation.*

Burning Solid Waste Has Advantages and Disadvantages

- **Waste-to-energy incinerators (Fig. 21-13)**
- 600 Globally
  - Most in Great Britain
- Advantages
- Disadvantages

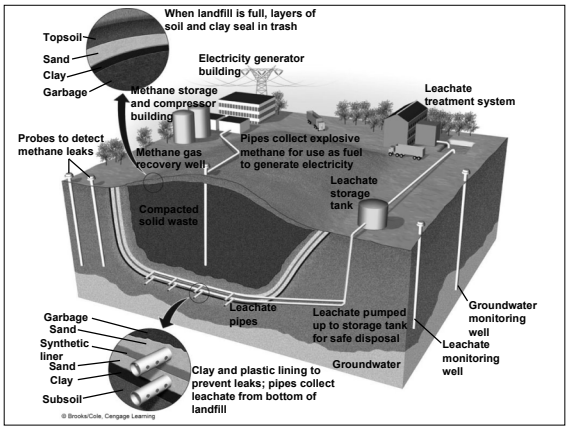


Trade-Offs: Incineration, Advantages and Disadvantages



Burying Solid Waste Has Advantages and Disadvantages

- Open dumps
- Sanitary landfills



21-5 How Should We Deal with Hazardous Waste?

- ***Concept 21-5*** *A sustainable approach to hazardous waste is first to produce less of it, then to reuse or recycle it, then to convert it to less hazardous materials, and finally, to safely store what is left.*

We Can Use Integrated Management of Hazardous Waste

- **Integrated management of hazardous wastes**
  - Produce less
  - Convert to less hazardous substances
  - Rest in long-term safe storage
- Increased use for postconsumer hazardous waste

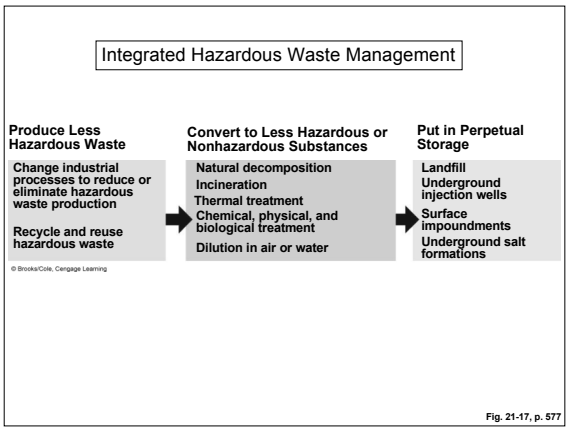
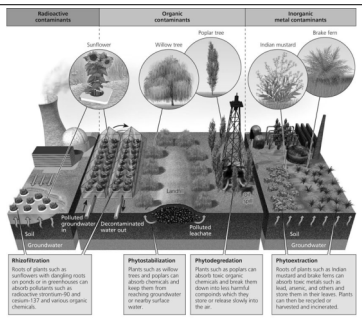


Fig. 21-17, p. 577

We Can Detoxify Hazardous Wastes

- Collect and then detoxify
  - Physical methods
  - Chemical methods
  - Use nanomagnets
  - Bioremediation
  - Phytoremediation
- Incineration
- Using a **plasma arc torch**

Solutions: Phytoremediation



TRADE-OFFS

Phytoremediation

Advantages	Disadvantages
Easy to establish	Slow (can take several growing seasons)
Inexpensive	Effective only at depth plant roots can reach
Can reduce material dumped into landfills	Some toxic organic chemicals may evaporate from plant leaves
Produces little air pollution compared to incineration	Some plants can become toxic to animals
Low energy use	

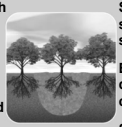


Fig. 21-19, p. 579

TRADE-OFFS

Plasma Arc

Advantages	Disadvantages
Small	High cost
Mobile. Easy to move to different sites	Produces CO_2 and CO
Produces no toxic ash	Can release particulates and chlorine gas
	Can vaporize and release toxic metals and radioactive elements

Fig. 21-20, p. 580

We Can Store Some Forms of Hazardous Waste

- Burial on land or long-term storage
- **Deep-well disposal**
- **Surface impoundments**
- **Secure hazardous landfills**

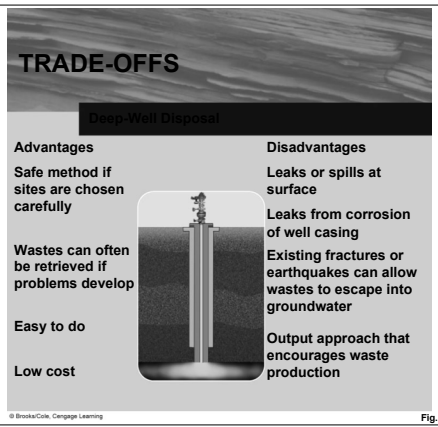


Fig. 21-21, p. 580

Surface Impoundment in Niagara Falls, New York, U.S.

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TRADE-OFFS

Surface Impoundments

Advantages

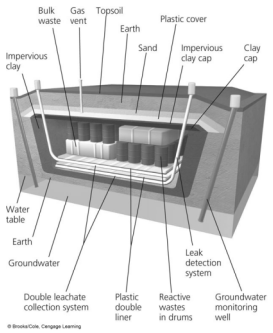
- Low construction costs
- Low operating costs
- Can be built quickly
- Wastes can often be retrieved if necessary
- Can store wastes indefinitely with secure double liners

Disadvantages

- Groundwater contamination from leaking liners (or no lining)
- Air pollution from volatile organic compounds
- Overflow from flooding
- Disruption and leakage from earthquakes
- Output approach that encourages waste production

Fig. 21-23, p. 581

Solutions: Secure Hazardous Waste Landfill



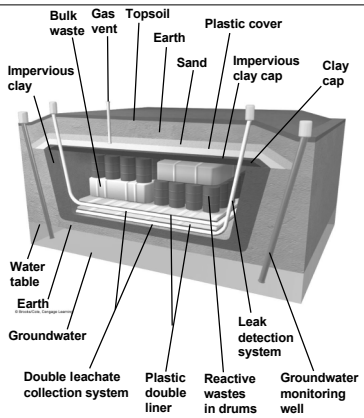


Fig. 21-24, p. 582

What Can You Do? Hazardous Waste

WHAT CAN YOU DO?

Hazardous Waste

- Avoid using pesticides and other hazardous chemicals, or use them in the smallest amounts possible
- Use less harmful substances instead of commercial chemicals for most household cleaners. For example, use vinegar to polish metals, clean surfaces, and remove stains and mildew; baking soda to clean household utensils and to deodorize and remove stains; and borax to remove stains and mildew.
- Do not dispose of pesticides, paints, solvents, oil, antifreeze, or other hazardous chemicals by flushing them down the toilet, pouring them down the drain, burying them, throwing them into the garbage, or dumping them down storm drains. Instead, use hazardous waste disposal services available in many cities.

Case Study: Hazardous Waste Regulation in the United States

- 1976: Resource Conservation and Recovery Act (RCRA)
- 1980: Comprehensive Environmental, Compensation, and Liability Act (CERCLA), or **Superfund**
  - Pace of cleanup has slowed
  - Superfund is broke
- Laws encouraging the cleanup of brownfields

Leaking Barrels of Toxic Waste at a Superfund Site in the United States

21-6 How Can We Make the Transition to a More Sustainable Low-Waste Society?

- ***Concept 21-6*** *Shifting to a low-waste society requires individuals and businesses to reduce resource use and to reuse and recycle wastes at local, national, and global levels.*

Grassroots Action Has Led to Better Solid and Hazardous Waste Management

- "Not in my backyard"
- Produce less waste
  - "Not in anyone's backyard"
  - "Not on planet Earth"

Providing Environmental Justice for Everyone Is an Important Goal

- **Environmental Justice**
- Which communities in the U.S. have the largest share of hazardous waster dumps?

Countries Have Developed International Treaties to Reduce Hazardous Waste (1)

- 1989 Basel Convention
  - 1995: Amended
  - 2008: Ratified by 192 countries, but not
    - The United States
    - Afghanistan
    - Haiti

Countries Have Developed International Treaties to Reduce Hazardous Waste (2)

- 2000: Delegates from 122 countries completed a global treaty
  - Control 12 persistent organic pollutants
- 2000: Swedish Parliament Law
  - By 2020 ban all chemicals that are persistent and can accumulate in living tissue

We Can Make the Transition to Low-Waste Societies

- Norway, Austria, and the Netherlands
  - Committed to reduce resource waste by 75%
- East Hampton, NY, U.S.
  - Reduced solid waste by 85%
- Follow guidelines to prevent pollution and reduce waste