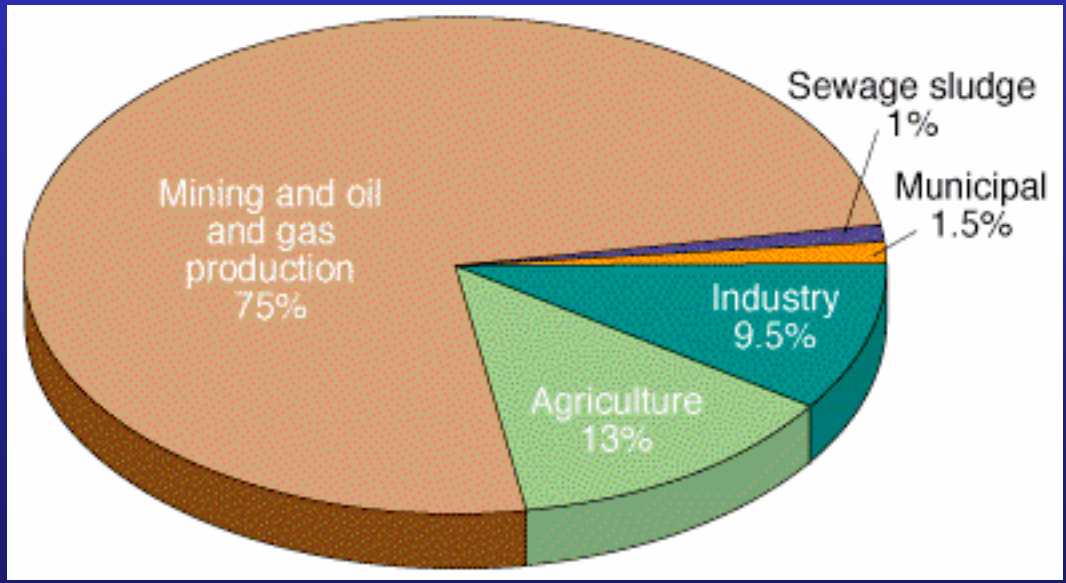
Solid & Hazardous Waste

tutorial by Paul Rich

1. Waste in Modern Society

The U.S., with only 4.6% of the world's population, produces about 33% of the world's solid waste.

- **solid waste**: any unwanted or discarded material that is not a liquid or gas;
- most solid waste comes from mining, oil, & natural gas production, agriculture, & industrial activities;
- only 1.5% of solid waste is **municipal solid waste**, from households & businesses.



Municipal Solid Waste

In the U.S., an average of 680 kilograms (1,500 pounds) per person of ***municipal solid waste (MSW)*** *is discarded each year (2–3 times more than other developed countries, & many times more than developing countries).*

- 27% of resources in MSW of U.S. were recycled in 1996;
- 58% dumped in landfills;
- 15% burned in incinerators & waste–to–energy plants.

Hazardous Waste

In the U.S. hazardous waste is defined as any discarded solid or liquid that

1) contains one or more of 39 toxic, carcinogenic, mutagenic, or teratogenic compounds that exceed established limits;
2) catches fire easily (gasoline, paints, & solvents);
3) is reactive or unstable such that it can explode or release toxic fumes

- does not include radioactive wastes, hazardous & toxic wastes discarded by households, mining wastes, oil & gas drilling wastes, liquid waste containing organic compounds, cement kiln dust, wastes from small businesses & industries;
- environmentalists call these omissions "linguistic detoxification".

2. Dealing with Solid and Hazardous Wastes

- **waste management**: views waste as an unavoidable product of economic growth, a high–waste approach that focuses on what to do with waste after it is produced;
- **waste prevention**: views waste either as potential resources (made available through recycling, composting, & reuse) or as harmful substances that we should not be using, a low–waste approach.

3. Waste Management

Managing waste involves difficult choices:

- **detoxification of hazardous waste** converts waste into less hazardous or non–hazardous materials;
- **burning solid & hazardous waste** reduces the quantity of waste (used for 15% of solid waste in U.S.), but contributes to air pollution & regulation can be difficult;
- **land disposal of solid & hazardous waste** involves burial or impoundment (used for 57% of solid waste in U.S.);
  - a **sanitary land fill** stores solid wastes in compacted layers that are covered daily with layers of clay or plastic foam;
  - most U.S. hazardous waste disposed by deep–well injections, surface impoundment, & state–of–the–art landfills;
- **exporting waste** involves shipping wastes to other countries.

Managing Hazardous Waste

Schematic of a waste-to-energy incinerator with pollution controls that burns mixed solid waste and recovers some of the energy to produce steam used for heating or producing electricity.

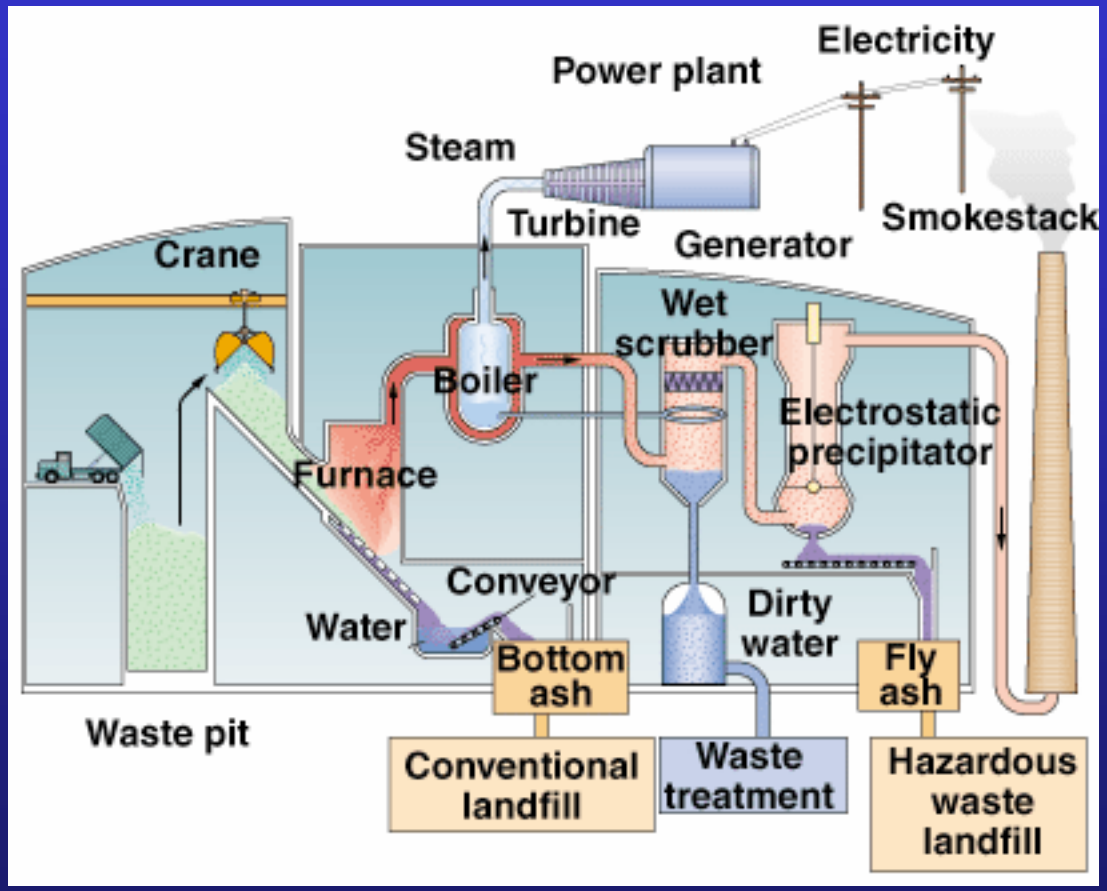
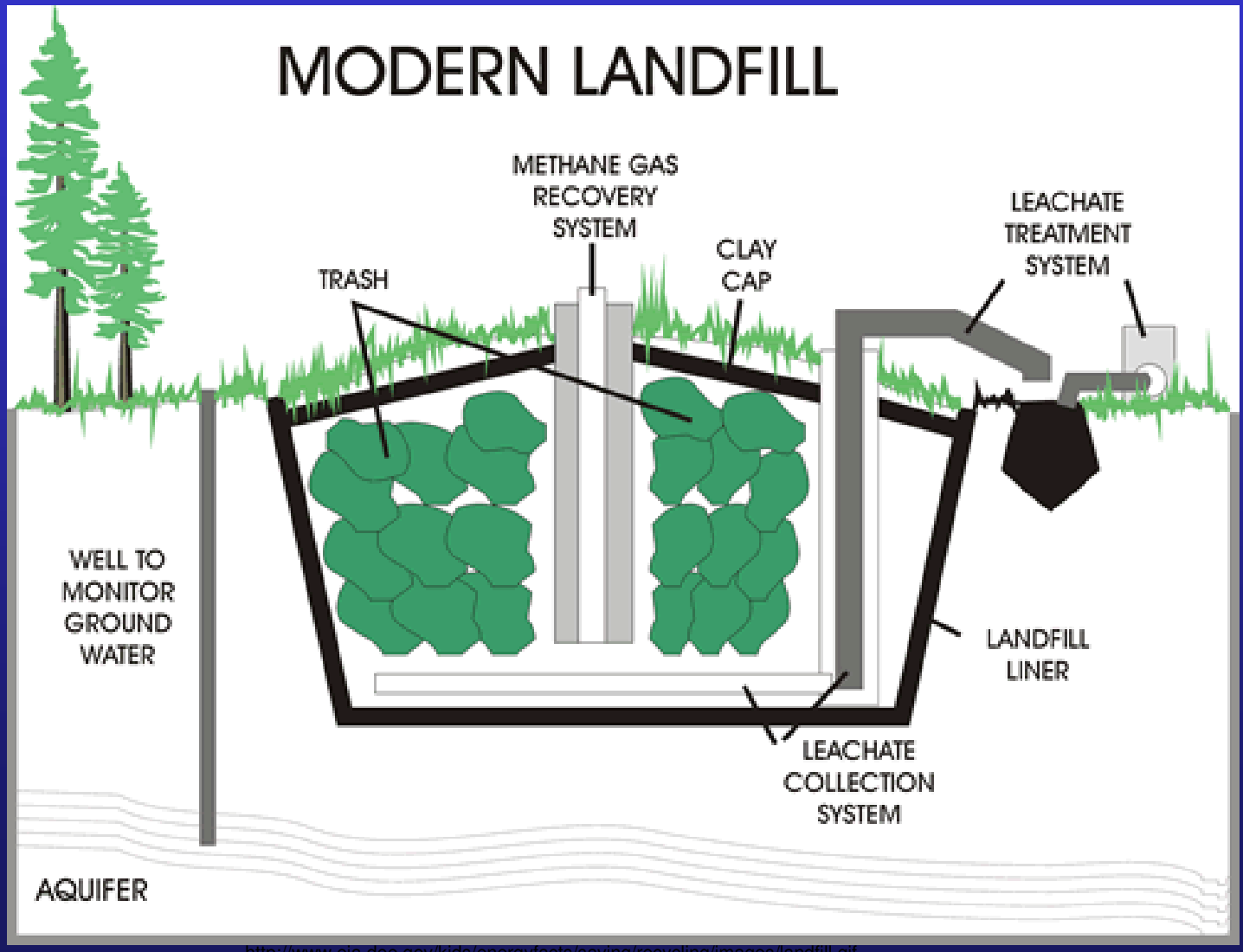


Fig. 22–9

Managing Hazardous Waste



http://www.eia.doe.gov/kids/energyfacts/saving/recycling/images/landfill.gif

Managing Hazardous Waste

Swedish method for handling hazardous waste. Hazardous materials are placed in drums, which are embedded in concrete cubes and stored in an underground vault.

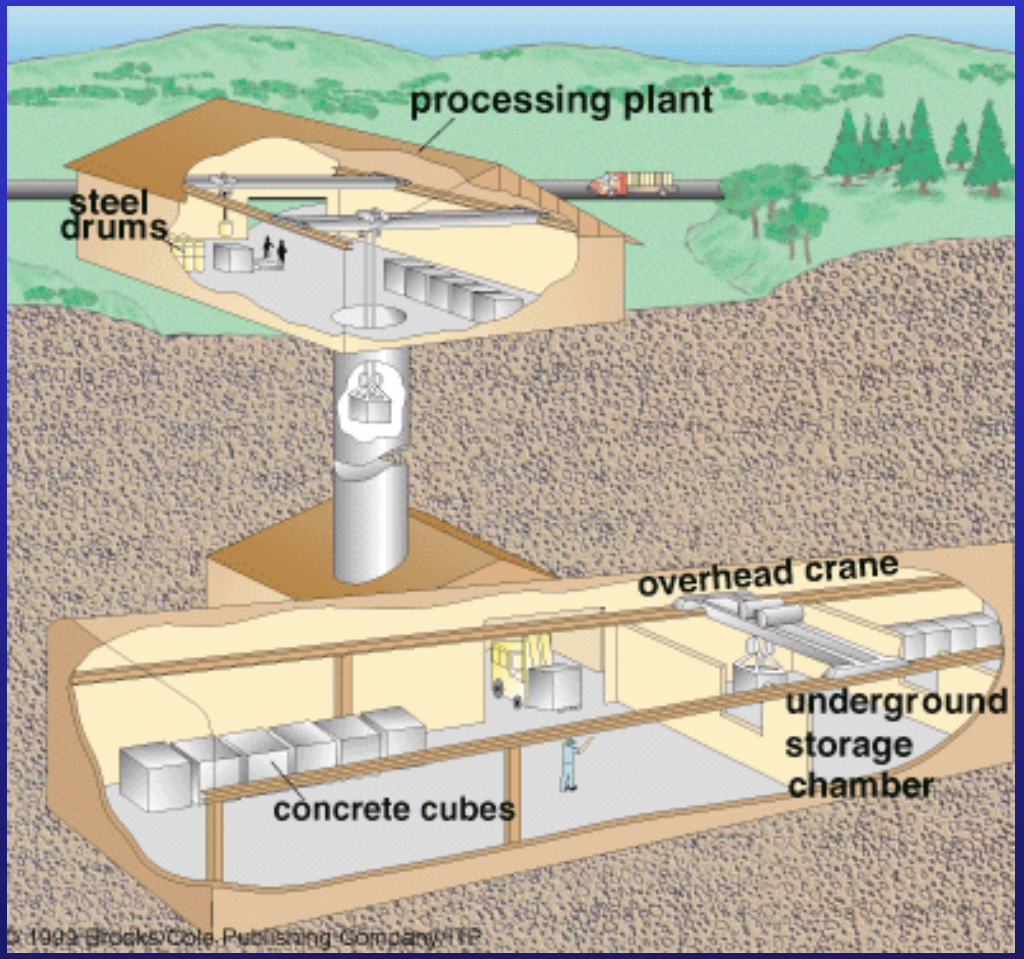


Fig. 22–11

Managing Hazardous Waste

In cases where hazardous waste can not be detoxified or safely burned, long–term impoundment may be the best option. Such storage can be expensive & entails risk of accidental release into the environment.

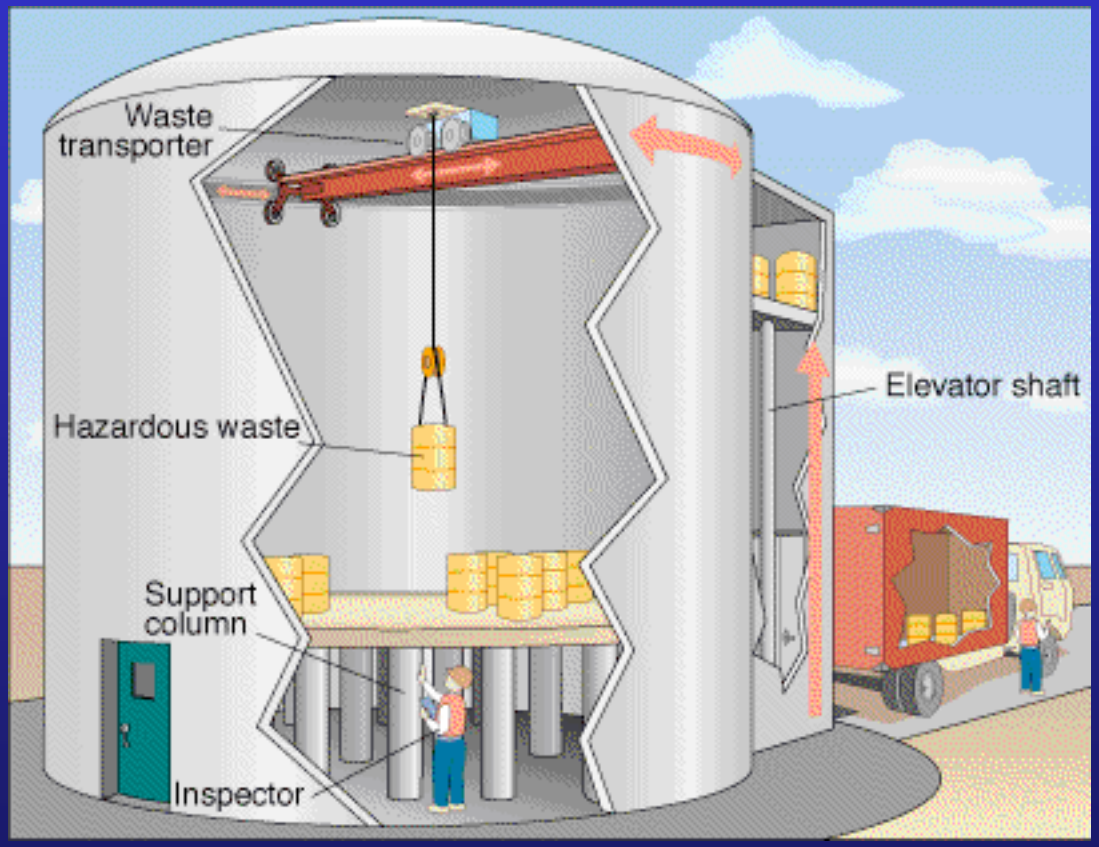


Fig. 22–12

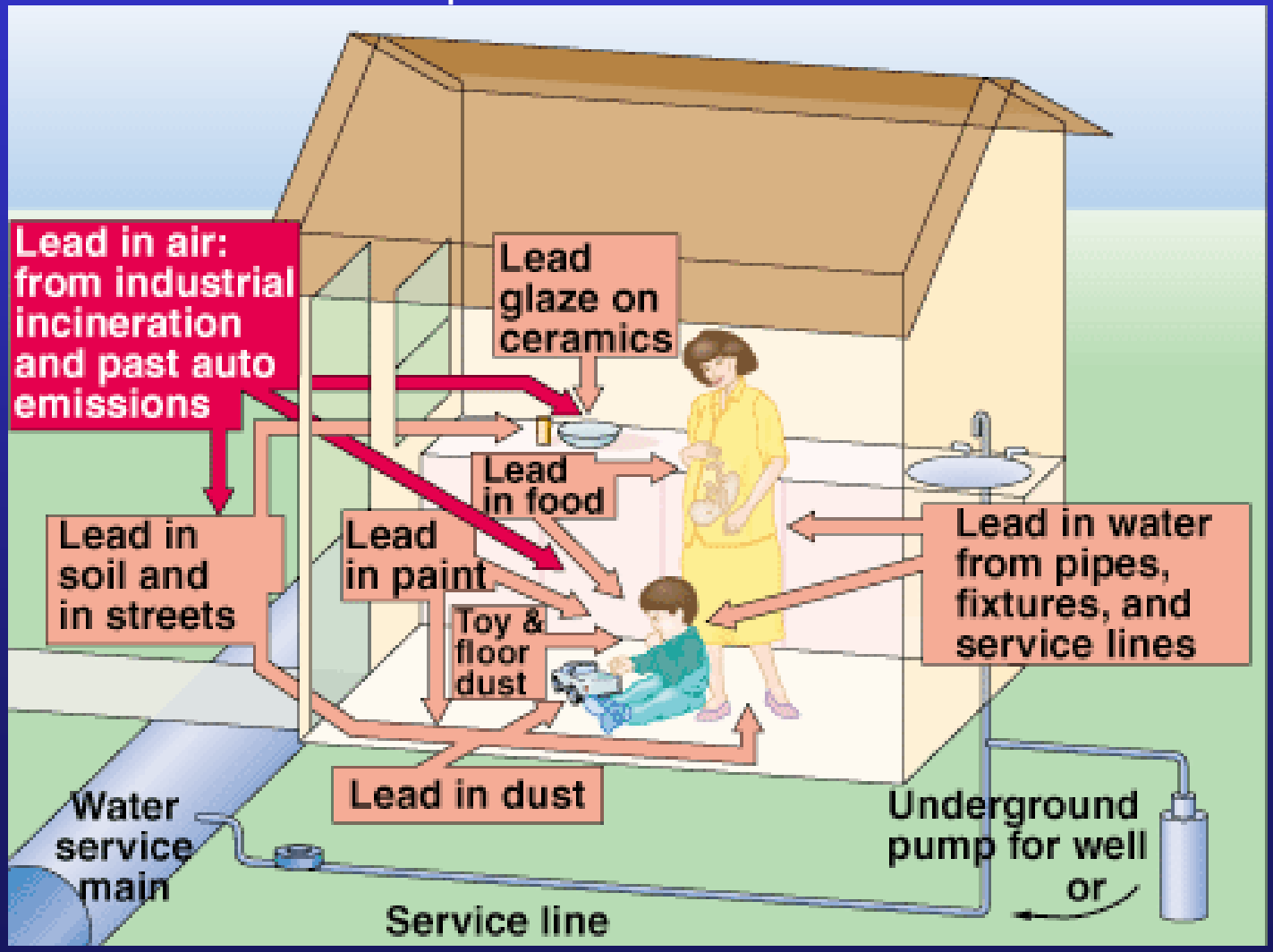
Case Study: Lead

Exposure to lead poses a serious health threat, especially for children.

- **acute lead poisoning** causes severe neurological problems; children who survive acute lead poisoning can display decline in mental capabilities, palsy paralysis, blindness, & mental retardation;
- lead is not easily excreted & accumulates in the body, such that **chronic lead poisoning** is a serious problem;
- lead exposure in the U.S. has decreased due to governmental regulations that phased out lead in gasoline & solder, however lead is commonly used in gasoline in developing countries;
- other sources of lead include old paint, plumbing, & ceramic glazes.

Case Study: Lead

Sources of lead exposure for children and fetuses



Case Study: Dioxins

Dioxins are a family of 75 chlorinated hydrocarbons formed as unwanted by–products in many manufacturing processes.

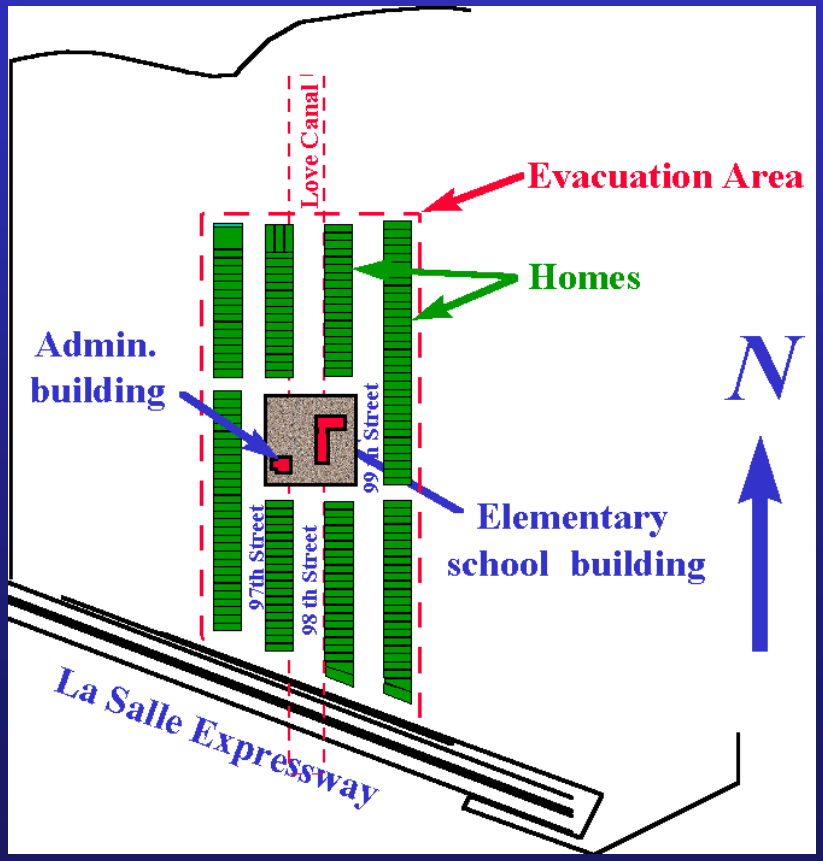
- dioxins promote cancer by activating DNA damaged by other carcinogens, cause reproductive problems, & weaken the immune system;
- in 1990, representatives of paper & chlorine industries claimed to have exonerated TCDD & other dioxins, but EPA's 1994 reevaluation found dioxins to be even more harmful than previously thought;
- dioxin can best be controlled at the sources: primarily medical waste incinerators, municipal solid waste generators, paper mills, iron ore sintering plants, & cement kilns used to burn hazardous wastes.

Case Study: Chlorine

Modern society depends heavily on chlorine & chlorine containing compounds.

- chlorine used to produce plastics, solvent, bleach paper & wood pulp, purify water, & produce household bleaching agents;
- many chlorine containing compounds are persistent, accumulate in body fat, & cause serious health problems;
- less harmful & affordable alternatives to chlorine are available for many uses, including cleaning solvents, paper production, & water purification.

Love Canal: A Toxic Nightmare



On April 28, 1953, the Niagara Falls School Board acquired title to the Love Canal property from Hooker Chemical for the fee of $1. The deed contained this disclaimer:

". . . .Prior to the delivery (sale). . . the grantee herein (school board) has been advised by the grantor (Hooker) that the premises above described have been filled, in whole or in part, to the present grade level thereof with waste products resulting from the manufacturing of chemicals by the grantor at its plant in the City of Niagara Falls, New York, and that the grantee assumes all risk and liability incident to the use thereof . . . ."

from the deed recorded July 6, 1953

City of Niagara Falls

Niagara County Clerk's Office

Lockport, New York

Hazardous Waste Regulation

U.S. hazardous waste is regulated by two major laws:

- **the Resource Conservation & Recovery Act** (RCRA, pronounced "RICK–ra") (passed 1976, amended 1984) requires the EPA to identify hazardous wastes & set standards for their management;
  - requires permits for firms that produce more than 100 kilograms (220 pounds) of hazardous waste;
  - "cradle to grave" system for tracking hazardous waste;
- the **Superfund Act** (passed 1980, amended 1986 & 1990) established a $16.3 billion Superfund to identify & clean up abandoned hazardous waste dump sites such as Love Canal;
  - cleanup is based on "polluter pays principle";
  - currently 1,360 sites on a National Priority List.

4. Waste Prevention

Priorities for dealing with material use & solid waste:

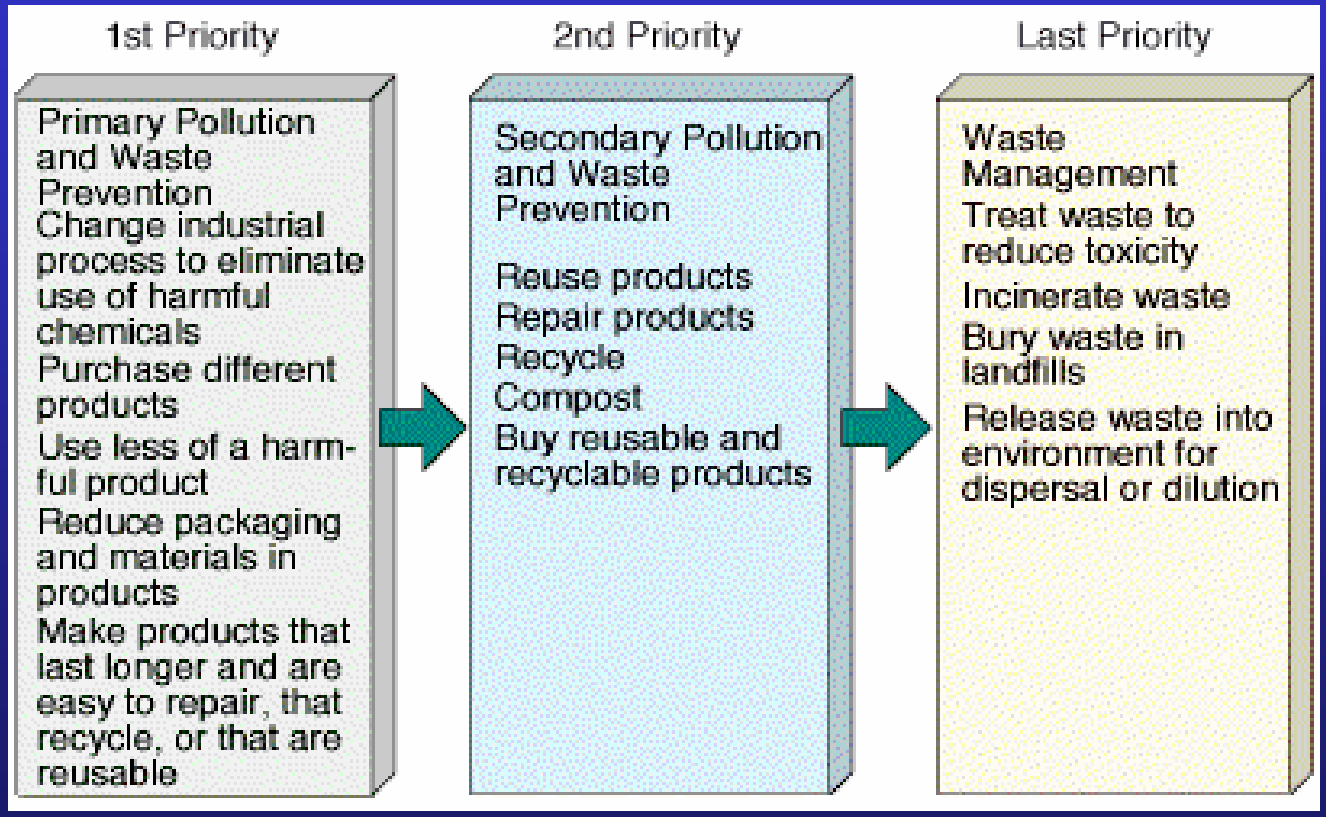


Fig. 22–3

Priorities for dealing with hazardous waste:

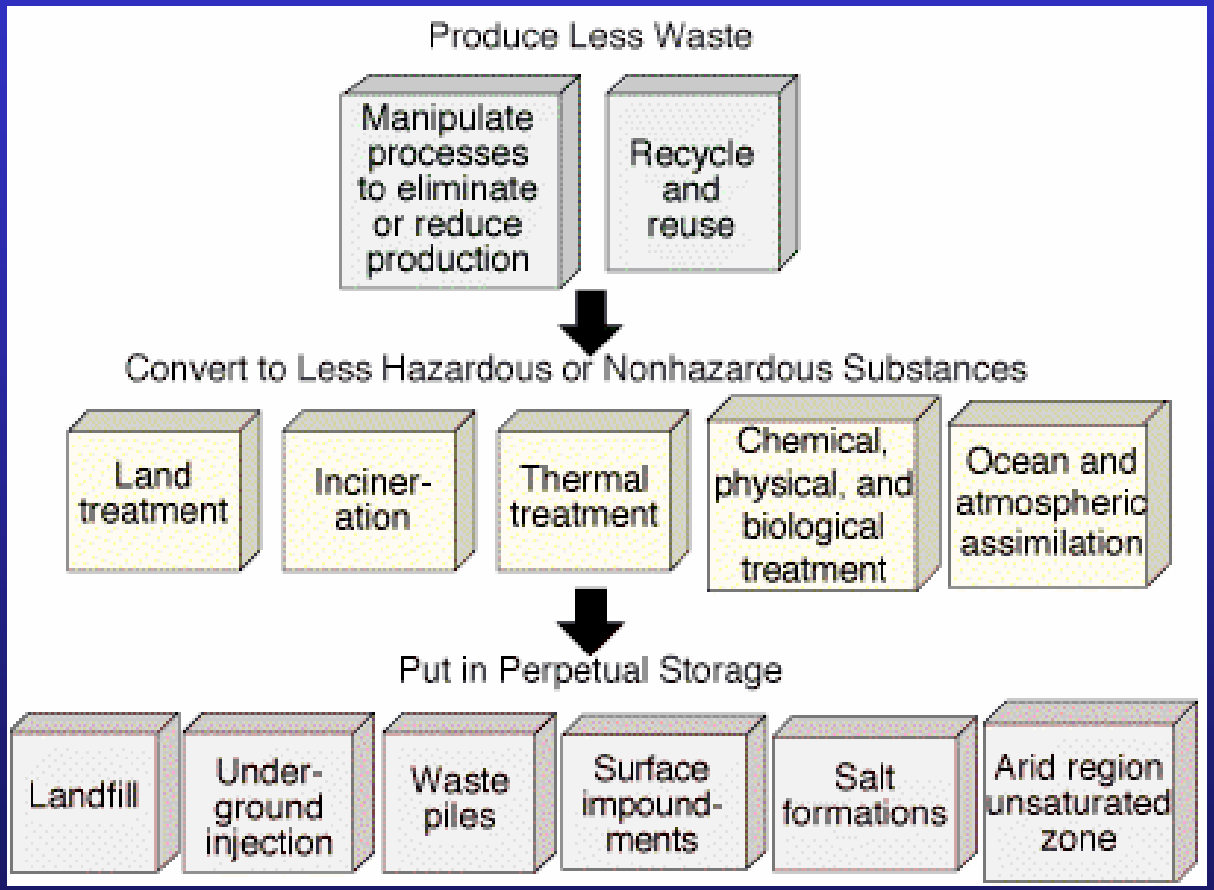


Fig. 22–4

Manufacturing Design

Manufacturing design can take into account waste production issues. Green design minimizes environmental impact by efficient use of energy & materials.

Green design builds "the three R's" (reduce, reuse, recycle) into the system.

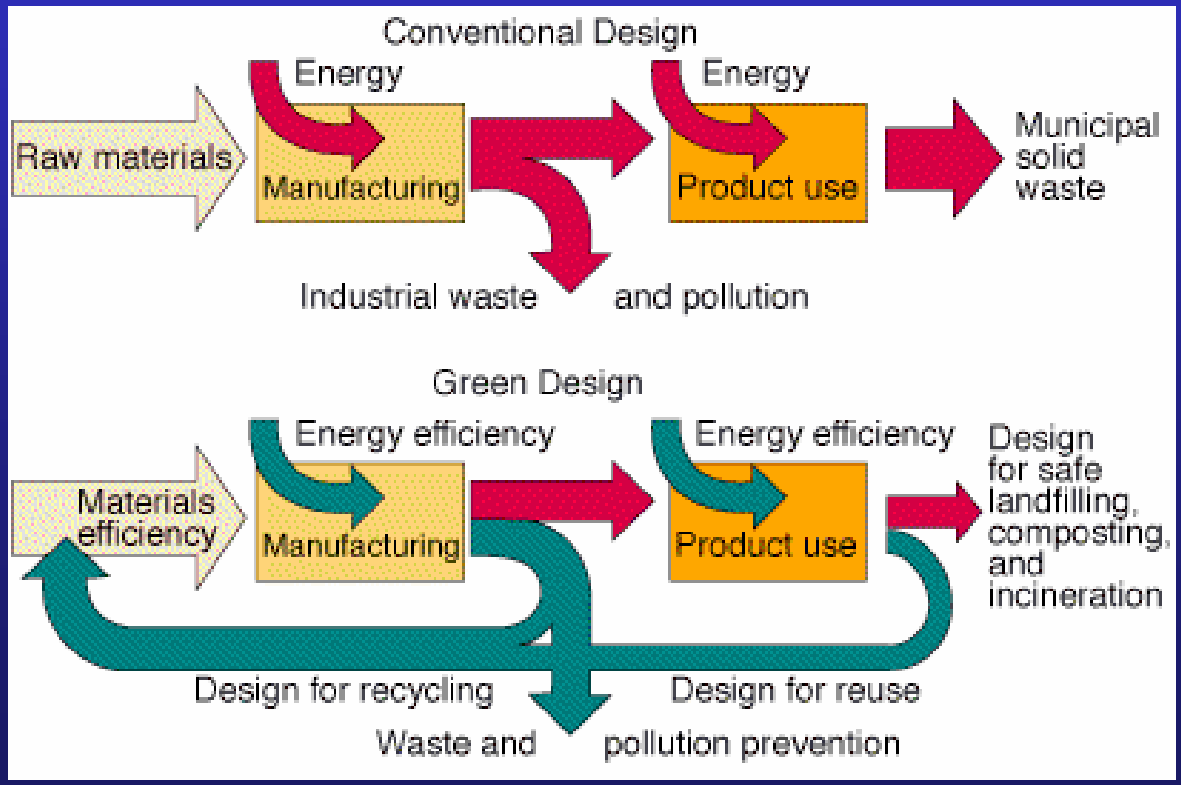


Fig. 22–5

Reduce

Reducing the production of waste is the most effective way of minimizing environmental impacts.

- ways to reduce waste:
  - decrease consumption;
  - redesign manufacturing processes to produce less waste;
  - produce durable goods that can be repaired or maintained;
  - eliminate unnecessary packaging;
  - promote consumer choice of green products;
  - institute "trash taxes" by charging for unnecessary waste.
- reducing waste can make good economic sense by reducing production costs, producing more desirable products.

Reuse

Reuse extends resource supplies by keeping high–quality matter resources from becoming low–quality waste.

- **refillable containers** reduce both material & energy waste:
  - in 1964, 89% of soft drinks & 50% of beer in U.S. were sold in refillable containers; in 1995 refillable containers are used for only 7% of the soft drink & beer market;
  - developing countries are shifting increasingly from refillable to non–refillable containers;
  - various developed countries are leading the way to use refillable containers (Denmark banned all non–refillable containers, Finland has 95% refillable containers, Germany has 73% refillable containers…);
  - various states in the U.S. require deposits on beverage bottles, but such legislation has been strongly opposed by the bottle industry.

Reuse

Sometimes the choice is clear & other times it is not.

- **reusable cloth or string bags** can reduce paper & plastic usage; the choice between paper & plastic bags is not so clear since plastic bags use less energy, but degrade slowly & use non–renewable resources, whereas, paper bags use more energy, degrade readily, & come from renewable sources;
- **disposable vs. cloth diapers:** the choice is not clear cut, since cleaning cloth diapers uses large amounts of energy & produces significant air & water pollution;
- **tires**, most of which end up in land fills (2.5–4 billion in U.S. alone), can be reused by retreading, used in construction (e.g., earth–fill houses), & used to create artificial reefs to attract fish.

Recycling

Recycling *involves various kinds of reuse of materials.*

- **composting** is a type of recycling in which organic materials are broken down by microorganisms to produce a humus-like material that can be used to condition soils;
- **primary recycling** (=**closed–loop recycling**) involves reusing materials, such as glass, metals, paper, & plastics, to produce materials of the same type (e.g., newspaper to make newspaper & aluminum cans to make aluminum cans);
- **secondary recycling** (=**open–loop recycling**) involves using waste materials to produce different products (e.g., glass bottles to produce aggregate for use in road construction).

Recycling Computers: http://thefutureschannel.com/dockets/hands-on_math/recycling_computers/swf/video.swf

Recycling

Centralized recycling involves sorting of waste materials after they are discarded, whereas source separation involves separation beforehand.

- separating recyclable & reusable materials from other waste makes more sense economically & has lower environmental impact;
- aluminum & paper, in particular, are worth a lot of money;
- many communities have established recycling centers with the concept that they should pay for themselves; in general, this is not economically feasible;
- recycling proponents contend that recycling centers should not be expected to pay for themselves any more than conventional waste disposal does.

Recycling

Aluminum recycling makes sense from environmental & economic perspectives.

- recycled aluminum produces 95% less air pollution, uses 97% less water, & requires 95% less energy than mining & processing aluminum ore;
- aluminum recycling is economically feasible because of the high mining & processing costs of using raw ore, such that the market price for recycled metal is high;
- many environmentalists view aluminum cans as unnecessary because they could be replaced by more energy–efficient & less polluting refillable glass or plastic bottles.

Recycling

Wastepaper recycling can make sense from environmental & economic perspectives.

- paper, especially newspaper & cardboard, is one of the easiest materials to recycle;
- for example, benefits of recycling Sunday newspapers: 1) uses 30–64% less energy, 2) reduces air pollution by pulp mills by 74–95%, 3) lowers water pollution by 35%, 4) prevents groundwater contamination by toxic ink leaching from landfills, 5) conserves large amounts of water, 6) saves landfill space, 7) creates five times more jobs, & 8) saves money;
- recycling **postconsumer waste** is beneficial because it is genuine recycling of materials that otherwise would be incinerated or end up in land fills;
- recycling **preconsumer waste** (scraps & cuttings from paper & printing plants) has always been done, & is therefore just a marketing ploy.

Recycling

Plastic recycling can be challenging.

- before recycling, plastics must be sorted by type, because of the many kinds of plastic resins;
- because the current price of oil is low, the price of virgin plastic resins is about 40% lower than recycled resins;
- PET, used for plastic beverage bottles, is an exception, in that recycled resins can be competitive in price;
- when plastics are recycled, they are often used in secondary recycling, producing products different than the original plastic (e.g., plastic construction materials & plastic bags can be made from beverage bottles).

Video:
http://www.history.com/media.do?action=clip&id=boneyard_garbagecastoff_broadband

Recycling

Schematic of a generalized materials-recovery facility used to sort mixed wastes for recycling and burning to produce energy. Because such plants require high volumes of trash to be economical, they discourage reuse and waste reduction.

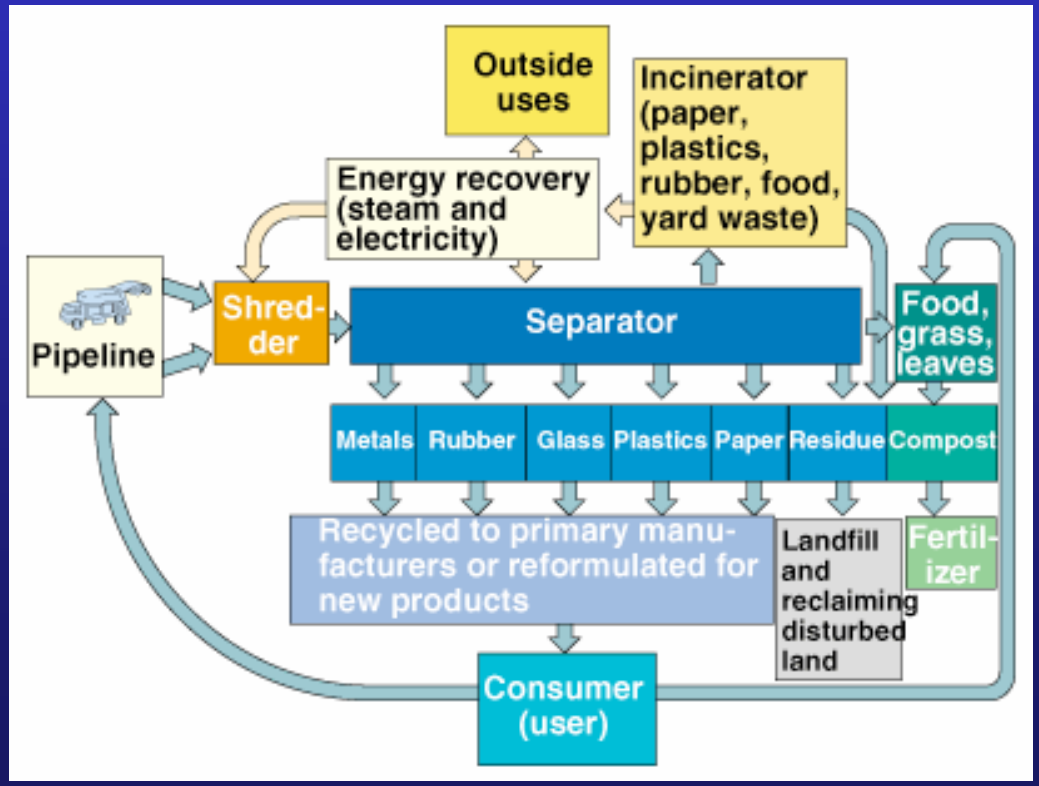


Fig. 22-6

5. Achieving a Low–Waste Society

- hierarchy of low waste approaches: 1) reduce, 2) reuse, 3) recycle & compost, 4) chemically & biologically treat, 5) bury.
- reducing, reusing, & recycling ("the three R's") are the most effective means, in that order;
- consumers can choose quality "green" products, that last a long time, have minimal environmental impacts during manufacture, and have parts that can be reused or recycled;
- low–waste practices can be "built into the system" by redesigning manufacturing processes & refocusing research & development efforts;
- grassroots efforts can support environmentally sound practices for incinerators, landfills, & treatment plants for hazardous & radioactive wastes.