Environmental Regulations: Hazardous Substances and Wastes

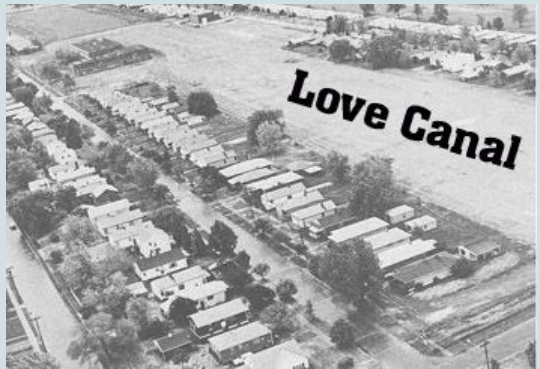
Chapter 19

Core Case Study: Love Canal — There Is No "Away"

- Between 1842-1953, Hooker Chemical sealed multiple chemical wastes into steel drums and dumped them into an old canal excavation (Love Canal).
- In 1953, the canal was filled and sold to Niagara Falls school board for $1.
- The company inserted a disclaimer
- denying liability for the wastes.

Love Canal —

- In 1957, Hooker Chemical warned the school not to disturb the site because of the toxic waste.
  - In 1959 an elementary school, playing fields and homes were built disrupting the clay cap covering the wastes.
  - In 1976, residents complained of chemical smells and chemical burns from the site.



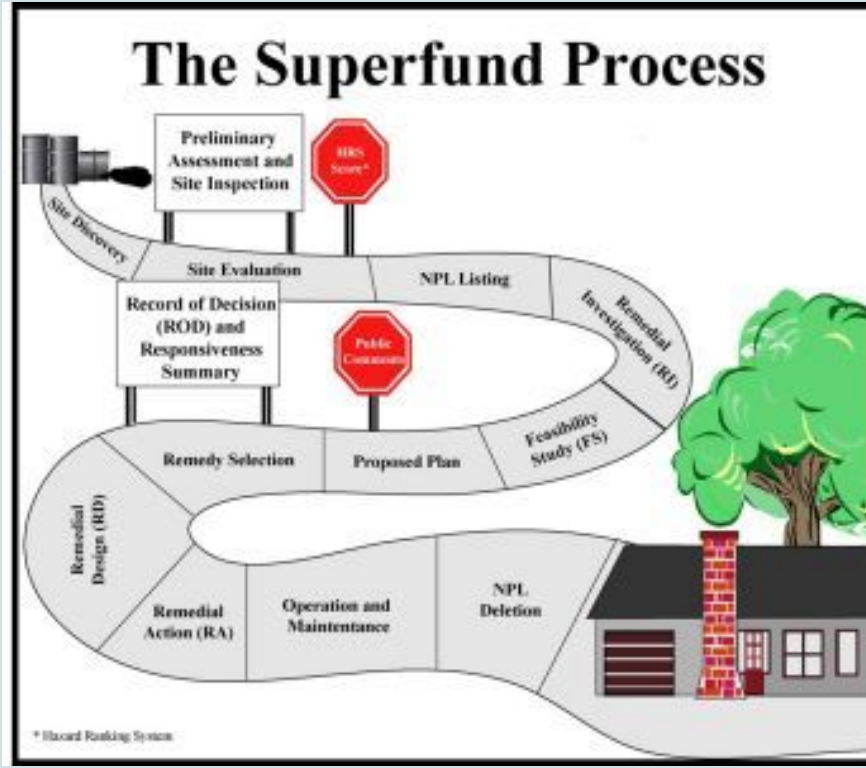
Love Canal —

- President Jimmy Carter declared Love Canal a federal disaster area.
  - The area was abandoned in 1980.

Figure 22-1

Love Canal —

- It still is a controversy as to how much the chemicals at Love Canal injured or caused disease to the residents.
- Love Canal sparked creation of the Superfund law, which forced polluters to pay for cleaning up abandoned toxic waste dumps.



Hazardous Waste Regulations in the United States

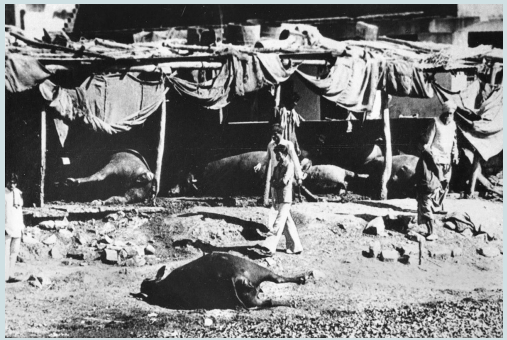
- The Superfund law (Comprehensive Environmental Response, Compensation, and Liability Act of 1980 - **CERCLA**) was designed to have polluters pay for cleaning up abandoned hazardous waste sites.
  - Only 70% of the cleanup costs have come from the polluters, the rest comes from a trust fund financed until 1995 by taxes on chemical raw materials and oil.

Minamata City, Japan 1956

- Petrochemical company released mercury compounds into Minamata Bay
- Converted to methylmercury by microorganisms
- Bioaccumulated in fish and shellfish
- Thousands sickened and high level of birth defects from “Minamata Disease”

Bhopal, India, 1984

- Methyl isocyanate gas leak from insecticide (Sevin)
- Considered worst industrial disaster
- 1000’s of deaths
- Official cause of disaster still debated



Chernobyl, Ukraine, 1986

- Meltdown and explosion of nuclear power plant
- Killed over 4,000
- Birth defects and cancers have increased

Abidjan, Cote d’Ivoire, 2006

- Ship dumped 500 tons of toxic waste
- Hydrogen sulfide, Sodium hydroxide and phenols
- 17 died, 1000’s injured from gas produced

Gulf of Mexico, 2010

- Deepwater Horizon explosion
- 4.9 million barrels of oil

West, Texas, 2013

- Fertilizer plant explosion (ammonium nitrate)
- 15 killed, 200 injured
- Cause unknown
- Only had $1 million liability insurance

Lac-Megantic, Quebec, 2013

- Runaway train hauling crude oil exploded
- 47 people killed
- Most of the downtown buildings destroyed
- Still under investigation

Hazardous Waste Regulations in the U.S.

- Other major federal law regulating the management and disposal of hazardous (and non-hazardous) waste in the U.S.:
  - Resource Conservation and Recovery Act (**RCRA**)
    - Cradle-to-the-Grave system to keep track of waste.

Hazardous Waste

- By-products of industrial, business or household activities.
- Any material that contains one or more of 39 toxic, carcinogenic, mutagenic or teratogenic compounds.
- Is reactive or unstable enough to explode, catch fire or release toxic fumes.
- Is capable of corroding metal containers such as tanks, drums, and barrels (including drain and oven cleaners).

HAZARDOUS WASTE

- The two largest classes of hazardous wastes are organic compounds (e.g. pesticides, PCBs, dioxins) and toxic heavy metals (e.g. lead, mercury, arsenic).

Household products	Waste generated
Plastics	Organic chlorine compounds
Pesticides	Organic chlorine compounds, organic phosphate compounds
Medicines	Organic solvents and residues, heavy metals (mercury, zinc, etc.)
Paints	Heavy metals, pigments, solvents, organic residues
Oil, gasoline and other petroleum products	Oils, phenols, heavy metals, ammonia, salts, acids, caustics
Metals	Heavy metals, fluorides, cyanides, acid and alkaline cleaners, solvents, pigments, abrasives, oils, phenols
Leather	Heavy metals, organic solvents
Textiles	Heavy metals, dyes, organic chlorine compounds, solvents

U.S. Laws Related to Hazardous and Toxic Materials: See p. 429 (Table 19.1)

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act), CAA (Clean Air Act), OSHA (Occupational Safety and Health Act), CWA (Clean Water Act), SDWA (Safe Drinking Water Act), HMTA (Hazardous Materials Transportation Act), TSCA (Toxic Substance Control Act), RCRA (Resource Conservation and Recovery Act), CERCLA (Comprehensive Environmental Response Compensation and Liability Act) - Superfund, SARA (Superfund Amendments and Reauthorization Act), SBLRBRA (Small Business Liability Relief and Brownfields Revitalization Act).

Voluntary Standards

- ASTM International Phase I Environmental Site Assessment Standard E-1527: prior assessment before start of project
- International Organization for Standardization ISO 14000 Certification - indication that environmentally conscious.

Managing Health Risks

- **Acute toxicity**: When exposed to one massive
- **Chronic toxicity**: Exposure to small doses over long periods
- **Synergism**: The combined effect of 2 or more chemicals may be greater than the sum of their separate effects.

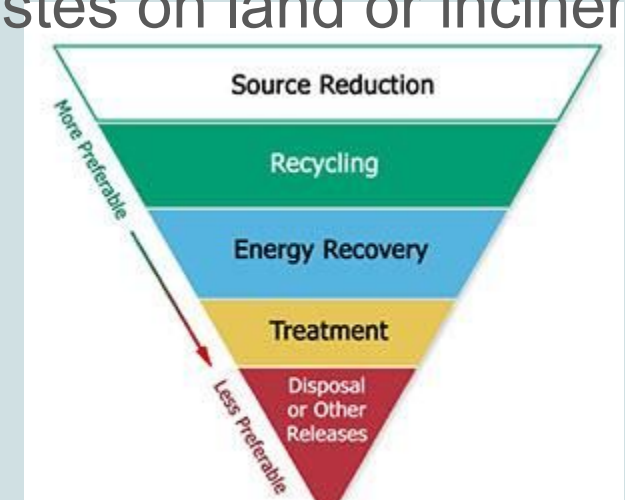
1 + 1 > 2 !

Persistent vs. Nonpersistent pollutants

- Persistent pollutants remain unchanged in environment for many years (Ex. DDT).
  - Most are human-made
- Nonpersistent pollutants biodegrade or decompose.

Pollution-prevention hierarchy (P2)

- Emphasizes reducing the amount of hazardous waste produced (Promoted by EPA)
  1. Reduce amount of pollution at the source
  2. Recycle waste wherever possible
  3. Treat wastes to reduce their hazard or volume
  4. Dispose of wastes on land or incinerate as last resort



Conversion to Less Hazardous Substances (treating wastes)

- ***Physical Methods***: using charcoal or resins to separate out harmful chemicals.
  - ***Carbon absorption***: Activated carbon chemically combines with waste to help collect it from gas or liquid.
  - ***Precipitation***: Adding materials to liquid waste to bind and settle out as floc.
  - ***Air stripping***: to remove volatile chemicals from water by force vaporization

Conversion to Less Hazardous Substances

- ***Plasma Torch***: passing electrical current through gas to generate an electric arc and very high temperatures can create plasma.
  - The plasma process can be carried out in a torch which can decompose liquid or solid hazardous organic material.

Conversion to Less Hazardous Substances (treating wastes)

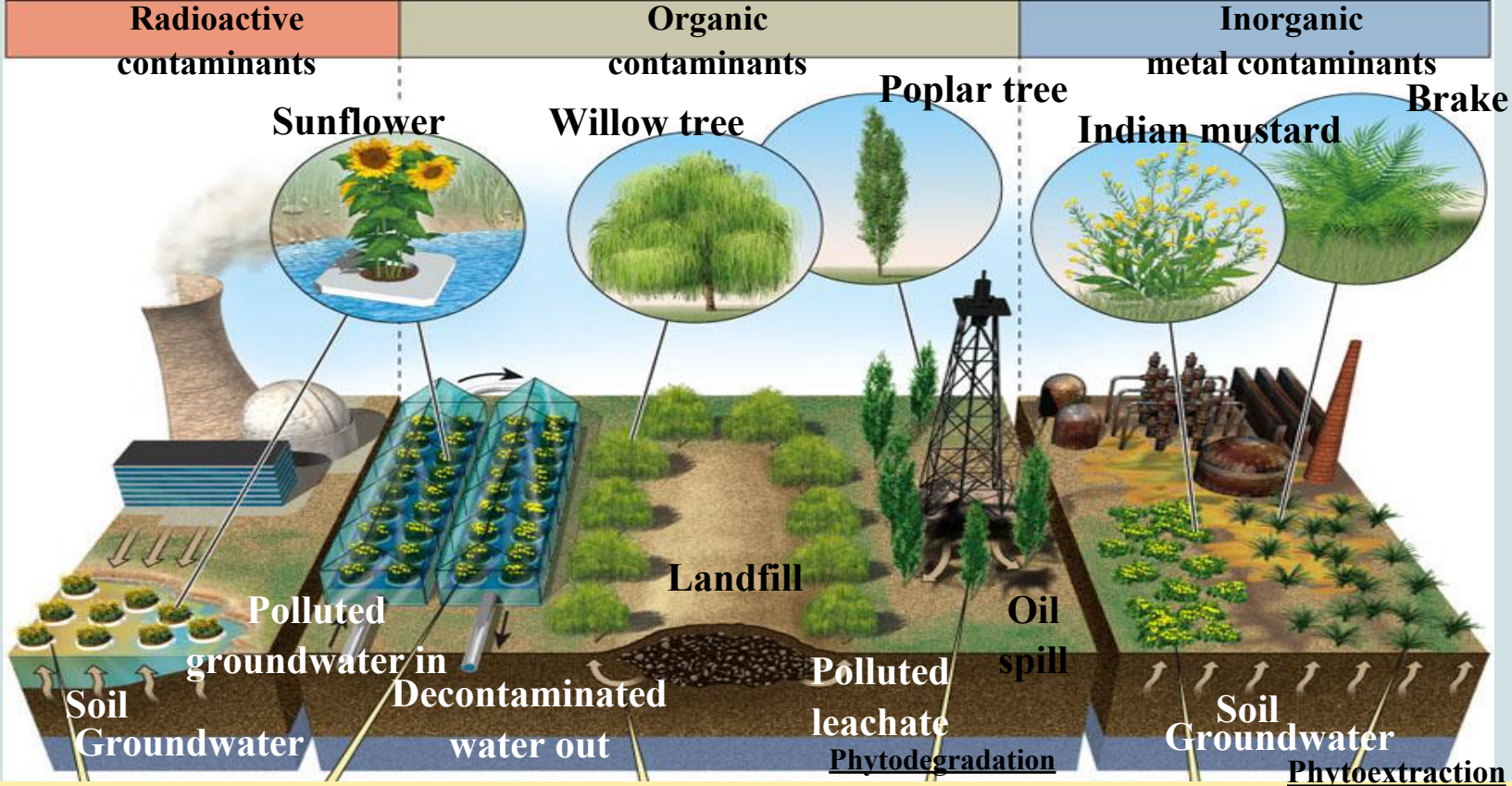
- ***Chemical Methods***: using chemical reactions that can convert hazardous chemicals to less harmful or harmless chemicals.
  - ***Neutralization***: Acids or bases reacted with one another.

Conversion to Less Hazardous Substances

- ***Incineration***: heating many types of hazardous waste to high temperatures – up to 2000 °C – in an incinerator can break them down and convert them to less harmful or harmless chemicals.

Conversion to Less Hazardous Substances

- ***Biological Methods***:
  - ***Bioremediation***: bacteria or enzymes help destroy toxic and hazardous waste or convert them to more benign substances.
  - ***Phytoremediation***: involves using natural or genetically engineered plants to absorb, filter and remove contaminants from polluted soil and water.



Rhizofiltration

Roots of plants such as sunflowers with dangling roots on ponds or in green-houses can absorb pollutants such as radioactive strontium-90 and cesium-137 and various organic chemicals.

Phytostabilization

Plants such as willow trees and poplars can absorb chemicals and keep them from reaching groundwater or nearby surface water.

Phytodegradation

Plants such as poplars can absorb toxic organic chemicals and break them down into less harmful compounds which they store or release slowly into the air.

Phytoextraction

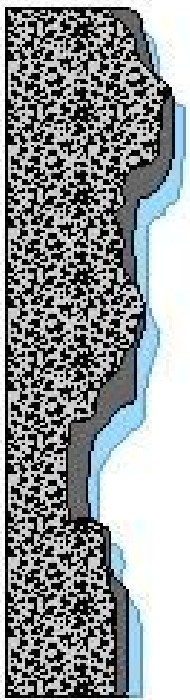
Roots of plants such as Indian mustard and brake ferns can absorb toxic metals such as lead, arsenic, and others and store them in their leaves. Plants can then be recycled or harvested and incinerated.

Long-Term Storage of Hazardous Waste

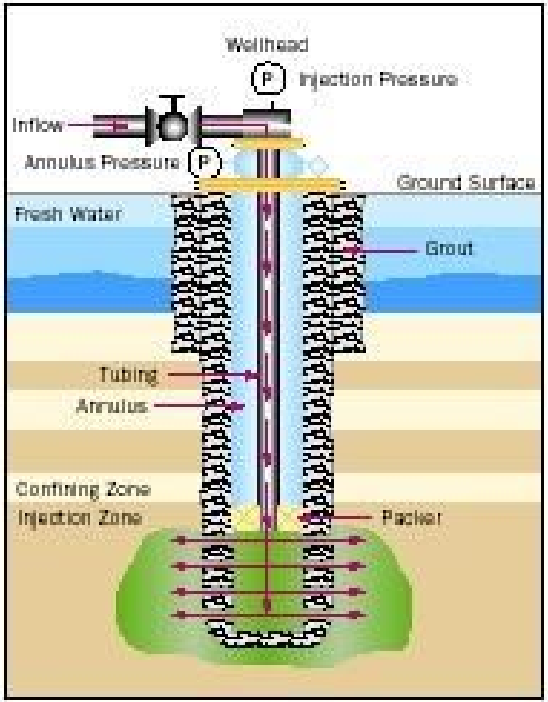
- Hazardous waste can be disposed of on or underneath the earth's surface, but without proper design and care this can pollute the air and water.
  - ***Deep-well disposal***: liquid hazardous wastes are pumped under pressure into dry porous rock far beneath aquifers.

    -Primary method (60%) for disposing of liquid waste.
  - ***Surface impoundments***: excavated depressions such as ponds, pits, or lagoons into which liners are placed and liquid hazardous wastes are stored.

DIAGRAM OF INJECTION WELL



Typical Injection Well



SOURCE: Adapted from the National Energy Technology Laboratory.

Trade-Offs

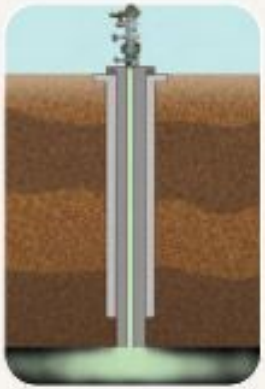
Deep-Well Disposal

Advantages

Safe if sites are chosen carefully

Wastes can often be retrieved

Low cost



Disadvantages

Leaks from corrosion of well casing

Emits CO_2 and other air pollutants

Output approach that encourages waste production

Surface impoundments

Trade-Offs

Surface Impoundments

Advantages

Low cost

Wastes can often be retrieved

Can store wastes indefinitely with secure double liners

Disadvantages

Groundwater contamination from leaking liners (and overflow from flooding)

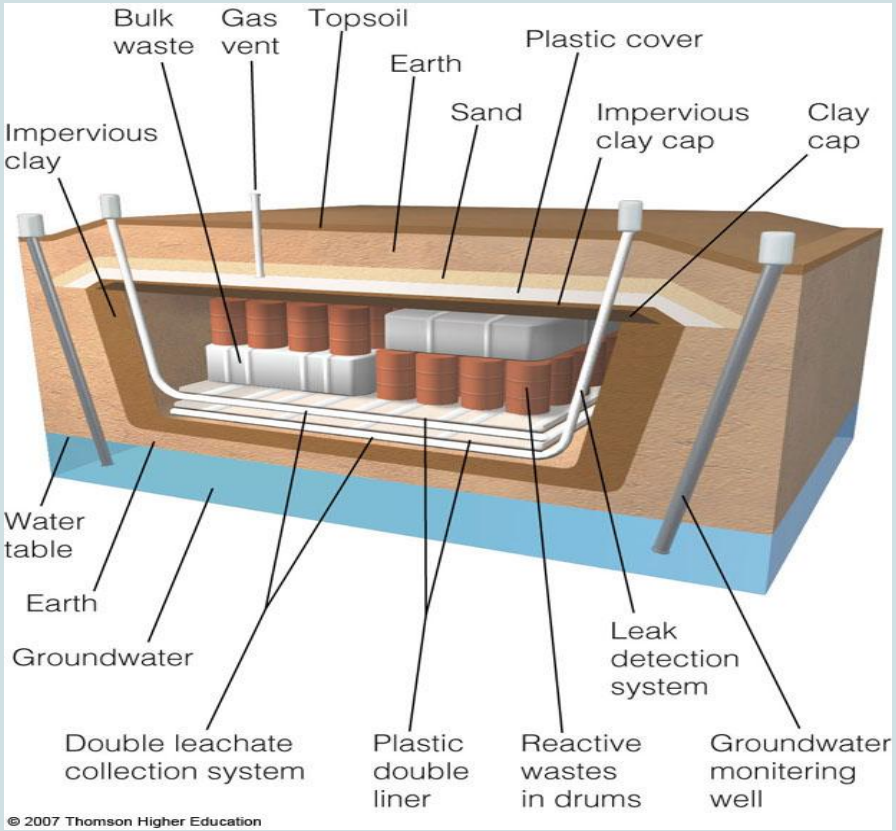
Air pollution from volatile organic compounds

Output approach that encourages waste production

Long-Term Storage of Hazardous Waste

- ***Long-Term Retrievable Storage***: Some highly toxic materials cannot be detoxified or destroyed. Metal drums are used to stored them in areas that can be inspected and retrieved.
- ***Secure Landfills***: Sometimes hazardous waste are put into drums and buried in carefully designed and monitored sites.

Secure Hazardous Waste Landfill



- In the U.S. there are only 23 commercial hazardous waste landfills.

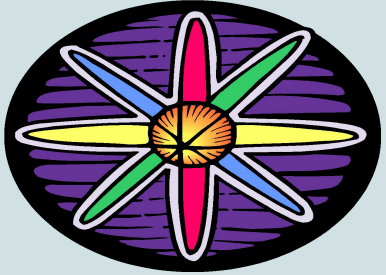
International Trade in Hazardous Wastes

- Cost effective but unsafe export of waste to developing countries lead to **Basel Convention:**

  - Under the United Nations Environment Programme in 1992

  - Goal to minimize generation of hazardous wastes and control/reduce transboundary movement (not all countries follow).

Nuclear Waste



- The safe disposal of radioactive wastes is a problem.
- Radioactive wastes must be stored in an isolated area where they can’t contaminate the environment.
- It must have geological stability and little or no water flowing nearby.

Four general categories of Nuclear Waste:

1. **Transuranic**: Usually from weapon production, highly radioactive with large numbers of atoms larger than uranium with half-lives > 20 years.

   - In the US, transported to the Waste Isolation Pilot Plant near Carlsbad, New Mexico.

Types of Nuclear Waste Continued

2. **Uranium Mining and Milling Waste**:

Preparation of uranium for weapons or energy.

- Low levels of radioactivity
- Fences, warning signs, land-use restrictions
- Usually cover with soil and rock

Types of Nuclear Waste Continued

3. **High-Level Radioactive Waste**: Spent fuel rods

- Some countries reprocess fuel rods (not US)
- *Temporary storage*: at nuclear sites, usually water-filled containers.
- *Permanent storage*: Bury in stable geologic formation (Finland, Sweden and U.S. have designated sites but facilities are not ready).

Types of Nuclear Waste Continued

4. **Low-Level Radioactive Waste**: From nuclear power or weapons facilities, hospitals and research.

- US disposes of 2 million cubic ft. per year.
- Buried in disposal sites in SC, WA, UT and TX.