



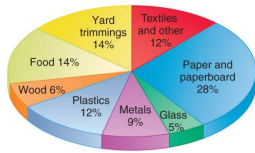


Outline

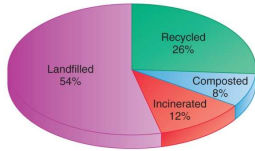
- **What Do We Do with Waste?**
- **Shrinking the Waste Stream**
 - Recycling
- **Hazardous and Toxic Wastes**
 - Federal Legislation
 - RCRA
 - CERCLA
 - Management Options

U.S. Domestic Waste

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(a) Amount generated, by weight



(b) Disposal methods

Waste Overview

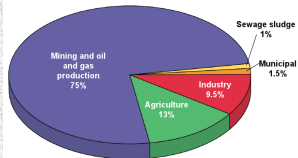
- **Solid Waste**
– any unwanted material that is not a liquid or a gas.
- The U.S. produces 11 billion tons per year
- **Waste Stream:** the steady flow of wastes that humans produce from all sources



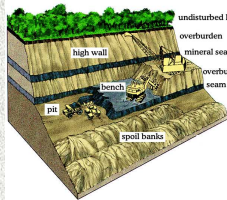
Sources of U.S. Waste

- Mining, oil and gas production produce 75% of waste
- **A large majority is spoil** (the dirt and rocks covering the resource that they want)

Sources of 12 Billion Tons of U.S. Solid Wastes Each Year...



*Note MSW is low!



Agricultural Waste 13% of waste ex: Corn, Rice Husks



Sources of U.S. Waste

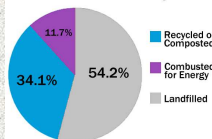
- **Industrial Solid Waste 10%:**
 - Scrap metal, plastics, paper, fly ash and sludge
 - Most is burned or buried on-site



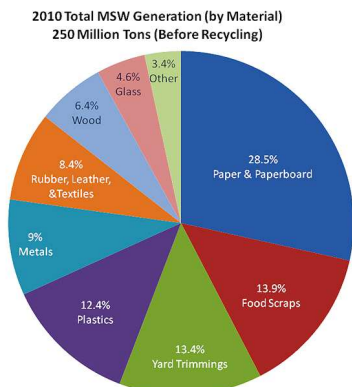
Sources of U.S. Waste

- **Municipal Solid Waste (MSW) 1.5%**
 - From homes and businesses
 - 1500 lbs per person per year

What Happens to Stuff We Throw Away*?



What is the largest % of MSW?



Disposal of Solid Waste: OPTIONS

- Open dumps
- Ocean Dumping
- Landfills
- Exporting
- Incinerating



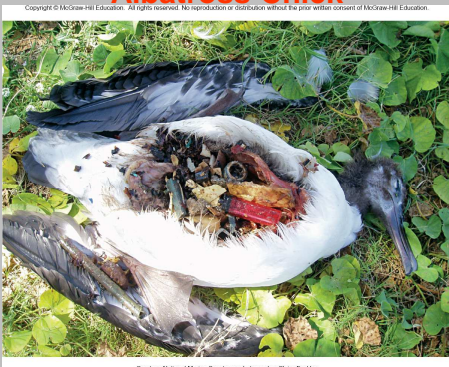
Waste Disposal Methods

- **Open Dumps Release Hazardous Materials**
 - Open, unregulated dumps are still the predominant method of waste disposal in developing countries.
 - Most developed countries forbid open dumping.
 - Estimated 200 million liters of motor oil are poured into the sewers or soak into the ground each year in the U.S.
 - About five times volume of *Exxon Valdez* oil spill

Waste Disposal Methods

- **Ocean dumping is nearly uncontrollable**
 - Every year 20 million tons of plastic debris are dumped at sea where they are eaten by wildlife or wash up on beaches, even in remote regions.
 - In the North Pacific alone, 50,000 northern fur seals are entangled in refuse and in the 1,000 km of fishing nets lost each year. They drown or starve to death.

Plastics In the Stomach of Albatross Chick



Waste Disposal Methods

- **We Often Export Wastes To Other Countries**
 - Industrialized nations have agreed to stop shipping hazardous and toxic waste to less-developed countries, but it still continues.
 - About 80% of electronic waste (e-waste) is shipped abroad, mostly to Asia and Africa where it is broken apart to salvage metals.
 - The remaining material is thrown into open dumps causing soil and water contamination.
 - Much of this e-waste is outdated televisions, computers, game consoles, and cell phones.

A Chinese Woman Extracts Valuable Metals From E-Waste



Waste Disposal Methods

▪ Sanitary Landfills

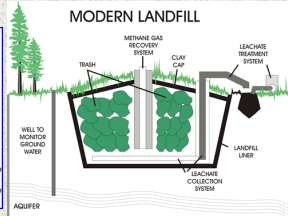
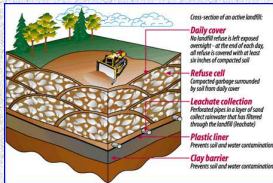
- Refuse compacted and covered every day with a layer of dirt
 - Dirt takes up as much as 20% of landfill space
- Since 1994, all operating landfills in the U.S. have been required to control hazardous substances with lining and drainage systems.

Sanitary Landfill



Sanitary Landfills

- Thin Layers of waste, compacted, and covered daily with a layer of clay, dirt, or foam.
- Surrounded by a thick, impermeable liner.
- A methane gas recovery system
- A leachate collection and treatment system.
- Monitor wells to make sure no leachate is flowing into the groundwater.



Landfills

- Historically, landfills have been a convenient, inexpensive waste-disposal option.
 - Rising land prices and shipping fees, and demanding construction and maintenance requirements, are increasing costs.
 - Suitable landfill sites are become scarce
 - 1,200 - 1,500 landfills have closed.
 - Communities are rejecting new landfills.
 - Positive trend in landfills is methane recovery

Open Dumps - Landfills

- Most common method for solid waste removal in developing countries
- Thousands of people live and work on dumps scavenging for food & recyclable materials in very unsafe conditions



Landfills

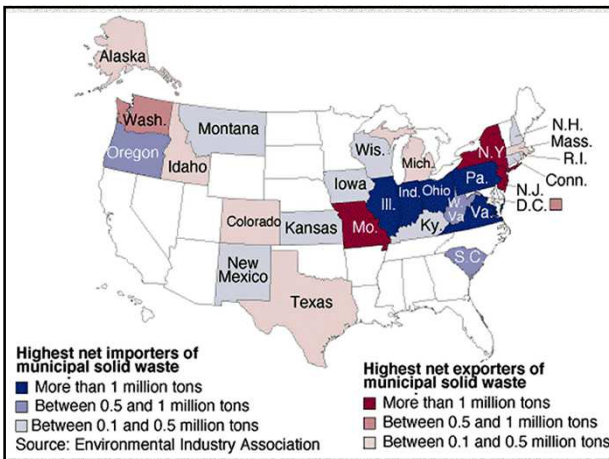
- 50% of all U.S. cities have used up landfill space
- Cities export trash (New Jersey, NYC)



Exporting Wastes

- Wastes get exported from developed to developing countries
- In 2011; 170 countries, agreed to accelerate a global ban on the export of hazardous waste, including old electronics and discarded computers and mobile phones, from developed to developing countries





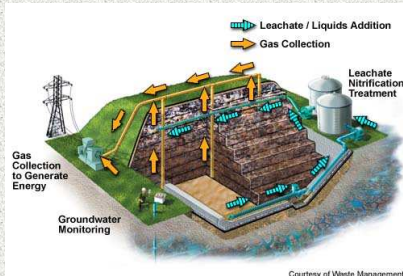
Landfill Problems

- Methane is a greenhouse gas that absorbs 25X more heat than CO₂.
- Risk of explosion
- Old landfills don't have impermeable liners. Leachate can contaminate groundwater.



Energy from Landfills

- Methane gas is produced by anaerobic microbes breaking down waste.
- Methane can be harvested for electricity.



Tires in Land Fills

- Tires are made of vulcanized rubber that is more difficult to be melted down or reused



Tires

- Can be **recycled** into playground equipment, garden hoses and soles of shoes
- **Reused** as artificial reefs to increase tropical fish populations – did not work



Waste Disposal Methods

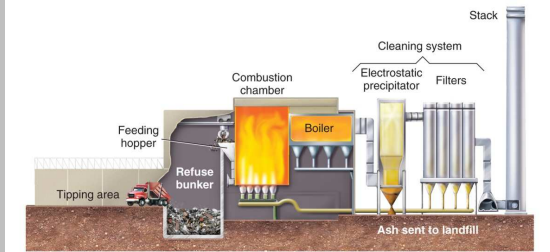
- **Incineration (also called Energy Recovery)**
 - **Energy Recovery** - heat derived from incinerated refuse is a useful resource
 - Burning garbage is used to create steam used for heating buildings or generating electricity.
 - Internationally, there are well over 1,000 such waste-to-energy plants that reduce garbage while generating needed energy.

Incinerator Types

- **Refuse-Derived Fuel** - refuse is sorted to remove recyclable and unburnable materials
 - Higher energy content than raw trash
- **Mass Burn** - everything smaller than major furniture and appliances loaded into furnace
 - Creates air pollution problems

Mass-Burn Incinerator

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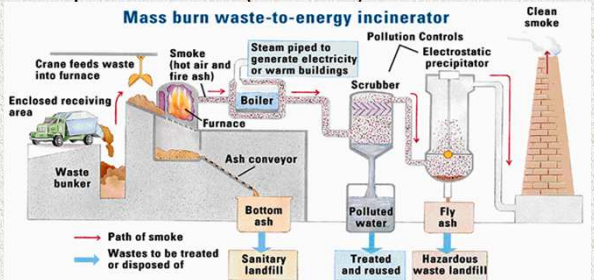
Incinerator Cost and Safety

- Initial construction costs are usually between \$100 and \$300 million for a typical municipal facility.
 - Tipping fees (cost to dump 1 ton) are often much higher than tipping fees at landfills.
- EPA has found alarmingly high levels of dioxins, furans, lead, and cadmium in ash.
- One way to control this is to remove heavy metals (batteries) and plastics before burning.

Incinerating Solid Waste – “Waste to Energy”

- Pro: Trash is burned, heat is used to generate electricity
- Cons: CO, particulates, heavy metals and toxic chemicals are produced. Expensive pollution control devices must be installed.
- 1000 plants world-wide (110 in U.S.)

Mass burn waste-to-energy incinerator



Types of Incinerators

- **Mass Burn**

- All trash is burned without separating out hazardous materials (batteries, plastics, etc.)
- Leftover ash must be disposed of in a hazardous materials landfill.



- **Refuse-Derived Fuels**

- MSW is sorted first (glass and metals removed)
- Dehydrated and shredded
- Left with mostly plastic and biodegradable waste that can be used as high quality fuel.
- Less air pollution

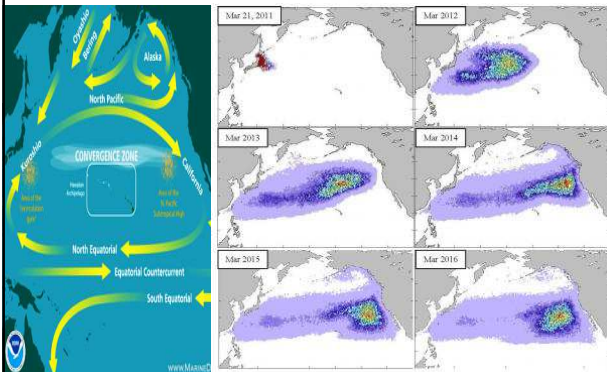


Ocean Dumping

- 55,000,000 lbs of trash are dumped in the sea every year



Waste from Japan Tsunami is going to join the great pacific garbage patch.



Ocean Dumping

- Ocean Dumping Ban Act of 1988, which prohibits all municipal sewage sludge and industrial waste dumping into the ocean.

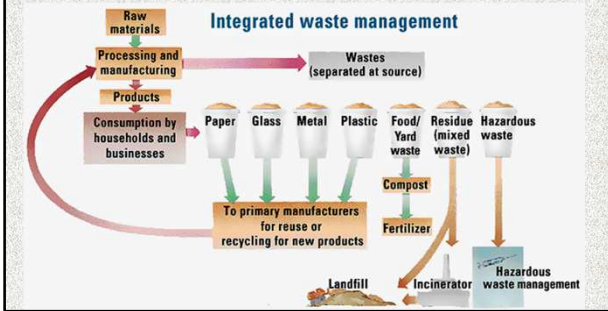


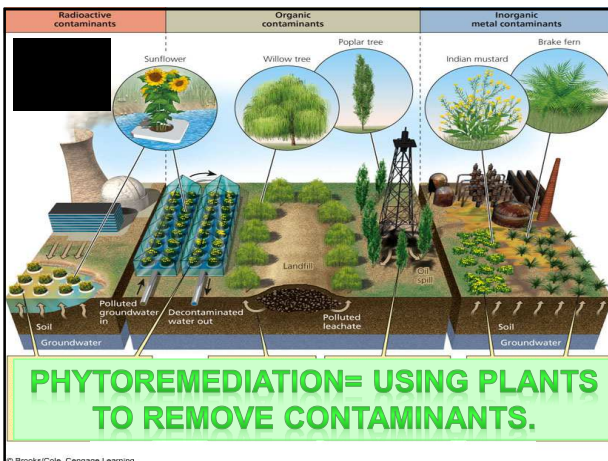
What about what has already been dumped?

Photo courtesy of the U.S. Army, In 1964, mustard gas canisters are pushed into the Atlantic Ocean off New Jersey.

Integrated Waste Management

- Finding the best use for discarded products – reuse, recycling, making compost, etc.
- Ex: at home how many MSW containers do you have?





PHYTOREMEDIATION= USING PLANTS TO REMOVE CONTAMINANTS.



Shrinking the Waste Stream

- **Recycling**
 - Recycling is the reprocessing of discarded materials into new, useful products.
 - Currently, about two-thirds of all aluminum cans are recycled.
 - Old tires are turned into road surface
 - Newspapers become insulation
 - Recycling copper is so lucrative that thieves are stealing copper pipes and wires, causing gas leaks and explosions.

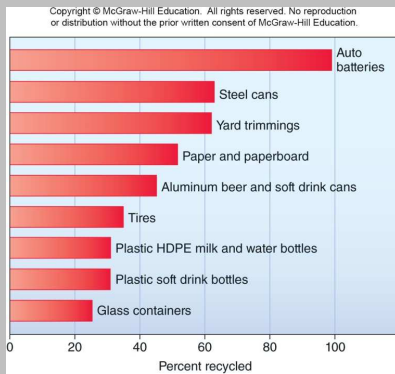
Recycling

- **Benefits**
 - Saves money, raw materials, and landfill space
 - Costs \$35/ton as opposed to \$80/ton to landfill
 - Encourages individual responsibility
 - Reduces pressure on disposal systems
 - Japan recycles about half of all wastes
 - Lowers demand for raw resources
 - Reduces energy consumption and air pollution

Recycling

- Present policies tend to favor use of new raw materials because energy, raw materials, and water are often sold below real cost to create jobs and stimulate the economy.
- You can help by buying recycled products.

U.S. Recycling Rates



Recycle Waste

- **Recycling:** melting down and reprocessing discarded materials into something new
 - Closed loop- same product after processing.
 - Ex: plastic bottle to a plastic bottle.
 - Open loop- different product after processing
 - Ex: plastic bottle to a drainage pipe.

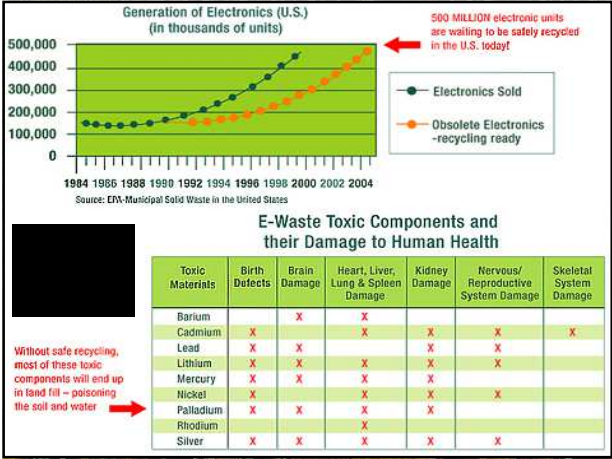


WOULD THIS BE OPEN OR CLOSED LOOP?

Recycling Aluminum Cans

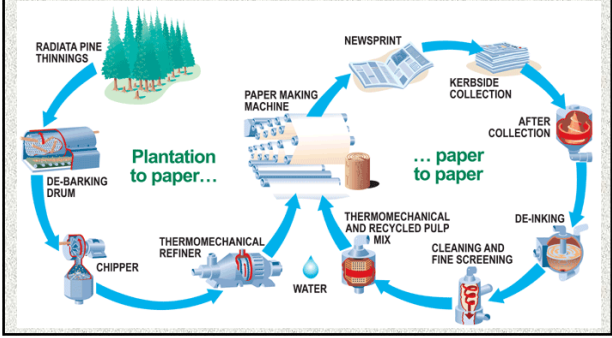
- What incentive do we have to recycle?
- In California all carbonated beverages sold in aluminum cans, glass bottles and plastic #1 (PET) bottles require a deposit. The deposit amount is 2.5¢ for containers under 24 ounces and 5¢ for containers at or above 24 ounces.
- Deposit is redeemable at any certified redemption center.
- 2/3 are recycled.





Recycle Paper

- One Sunday paper requires 500,000 trees.
- 40% of paper is recycled today.



Recycling Metals Other than Aluminum

- Copper, Leadiron, steel, zinc, etc. are also profitable to recycle
- Sometimes difficult to extract from municipal solid waste because waste products are not pure metal











Recycling Plastic

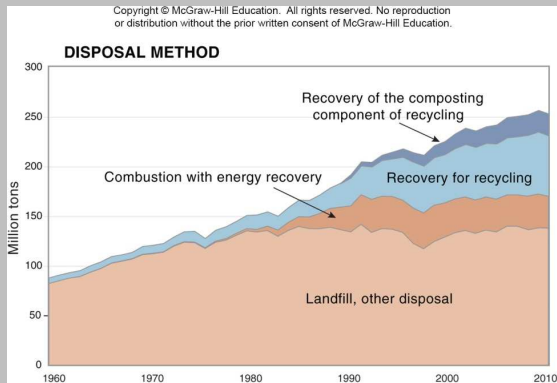
- Only about 2.5% of plastic is recycled
- Plastic is more difficult to recycle than paper, aluminum, and glass
- Polyethylene bottles are the exception, up to 40% are recycled



Be Plastic-Smart - check recycling codes on plastics

 <p>1 PETE can contain BPA often leach phthalates don't re-use don't expose to heat</p>	 <p>2 HDPE safer option</p>	 <p>3 V contains numerous toxic chemicals/ human carcinogens</p>
 <p>4 LDPE safer option</p>	 <p>7 Other contains BPA don't expose to heat</p>	 <p>5 PP safer option</p>
 <p>6 known to release toxins incl. styrene, especially when heated</p>	<p>Give Me Life </p>	

Disposal of Municipal Waste



Commercial Scale Recycling and Composting

- **Compost yard waste at the municipal level**
 - Yard waste makes up 12% of waste stream.
 - Swiss company uses yard waste to make methane.
 - Construction waste can be recycled.
 - Gasifiers convert biomass (food-soaked paper) to natural gas.

E-Waste

- **Demanufacturing is the disassembly and recycling of obsolete appliances and electronics.**
 - Most office machines are used 3 years; most TVs used 5 years; 300 million computers await disposal
 - 70% of heavy metal contamination comes from e-waste, and batteries make up another 10% to 20%.
 - In Europe, manufacturers have “cradle to grave” responsibility for their products.

Reuse is More Efficient Than Recycling

- Auto parts, brass fittings, woodwork, bricks, are routinely reused and can bring a high price.
- Glass and plastic bottles are washed and refilled.
- In developing countries, poor people make a living by scavenging, sorting, and reprocessing scraps from dumps.

Shrinking the Waste Stream

- **Producing Less Waste**
 - Excess packaging of consumer products is one of our greatest sources of unnecessary waste.
 - Paper, plastic, glass, and metal packaging material make up 50% of domestic trash. We can:
 - Decrease unnecessary packaging;
 - Increase use of photodegradable and biodegradable plastics.
- By 2020, new laws in the European Union mandate that 50% of municipal solid waste and 70% of construction waste will be reused or recycled.

Reducing Waste

- Reduce consumption
- Reduce packaging (50% of domestic waste)
- Trash taxes, increase cost.
- Also, **modify** waste
 - Photodegradable and biodegradable plastics

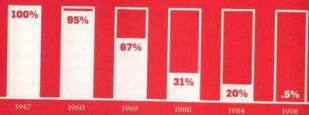


After Reduce? REUSE!

- Can Refillable Bottles Make a Comeback?
 - In 1947 100% of soft drinks, today <.5%
 - Drinks Cost 1/3 less in refillable bottle...why?

THE DECLINE OF REFILLABLE BEVERAGE BOTTLES IN THE US

SOFT DRINKS SOLD IN REFILLABLE BOTTLES



Reuse Waste

- Make purses from plastic bags
- Use fabric bags for groceries
- Reuse car parts, motor oil etc.

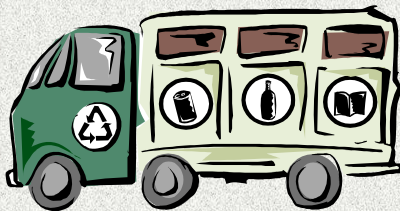


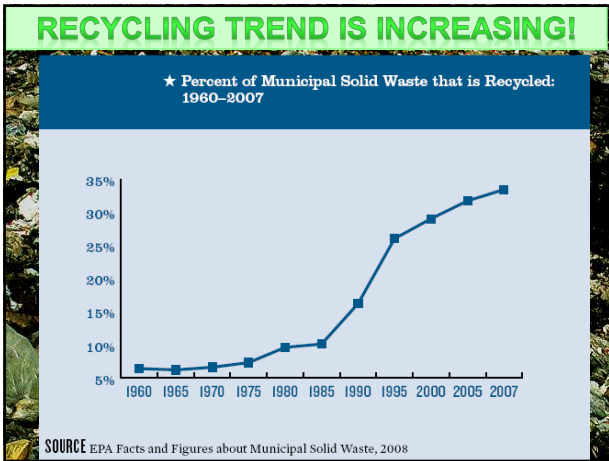
After Reuse? RECYCLE!

What is recycling?

We can recycle:

- Paper
- Glass
- Aluminum
- Metals
- Plastic
- Tires
- Styrofoam





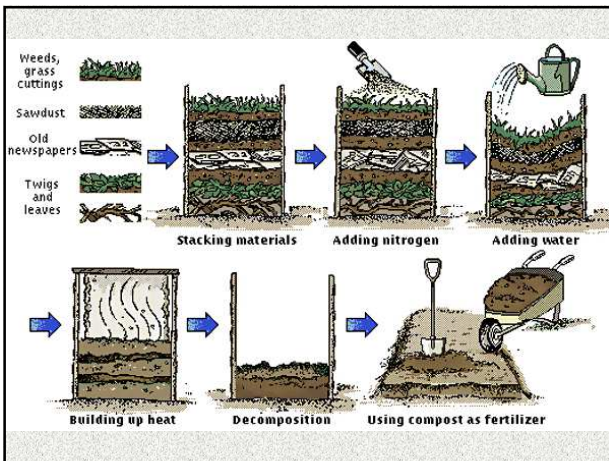
Composting

- recycling of organic waste into organic fertilizer.
- Food waste , yard clippings are broken down by microorganisms.

From Garbage to Garden
It's Compost Time!

Put these in

Keep these out



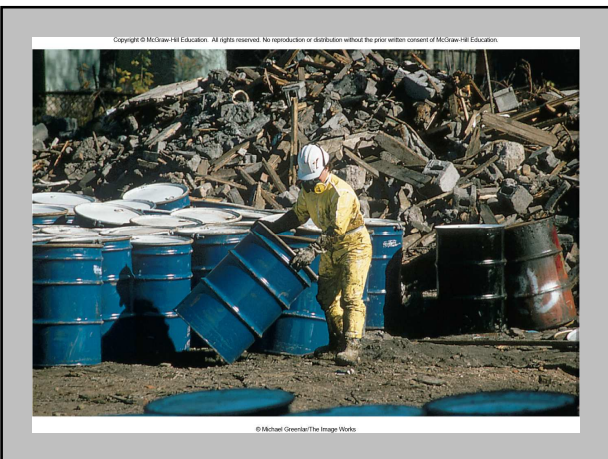
Grassroots Action Has Led to Better Solid and Hazardous Waste Management

- **NIMBY - “Not in my backyard”**



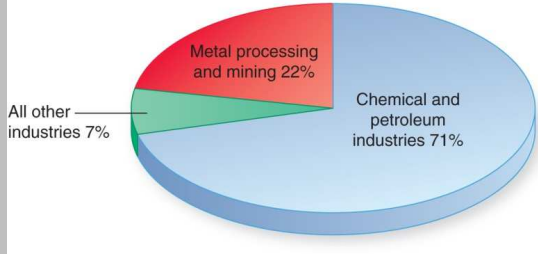
Hazardous and Toxic Wastes

- EPA estimates U.S. industries generate 265 million metric tons of officially classified hazardous wastes annually.
 - At least 40 million metric tons of toxic and hazardous wastes are released into the environment each year.



U.S. Hazardous Waste Producers

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Hazardous Waste

- Legally, hazardous waste is any discarded liquid or solid that contains substances known to be:
 - Fatal to humans or laboratory animals in low doses;
 - Toxic, carcinogenic, mutagenic, or teratogenic to humans or other life-forms;
 - Ignitable with a flash point less than 60° C;
 - Corrosive; or
 - Explosive or highly reactive.

Hazardous Waste Disposal

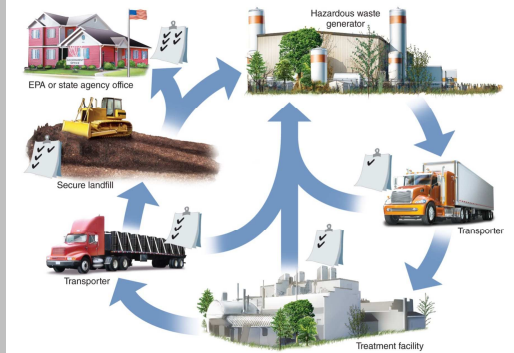
- Federal Legislation
 - Resource Conservation and Recovery Act (RCRA) - 1976
 - Comprehensive program requiring rigorous testing and management of toxic and hazardous substances
 - “Cradle (point of generation) to grave (ultimate disposal)” accounting

Federal Legislation

- **Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 1980**
 - Modified by Superfund Amendments and Reauthorization Act (SARA) 1984
 - Aimed at rapid containment, cleanup, or remediation of abandoned toxic waste sites
 - Establishes a community “right to know”
 - **Toxic Release Inventory** - Requires 20,000 manufacturing facilities to report annually on releases of more than 300 toxic materials

Tracking Cradle to Grave

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CERCLA

- **Government does not have to prove anyone violated a law or what role they played in contaminating a superfund site**
 - Liability under CERCLA is “strict, joint, and several,” meaning anyone associated with a site can be held responsible for the entire clean-up cost
 - CERCLA amended in 1995 to allow containment if treatment is unavailable or too costly

Superfund Sites

- EPA estimates 36,000 seriously contaminated sites in the U.S. General Accounting Office says 400,000 sites.
 - By 2007, 1,680 sites had been placed on the National Priority List for cleanup with Superfund financing.
 - Superfund is a revolving pool designed to:
 - Provide immediate response to emergency situations posing imminent hazards; and
 - Clean-up abandoned or inactive sites.
 - In 1995 Congress let the “polluters pay” tax expire.
 - Today, tax payers absorb the cost of clean up.

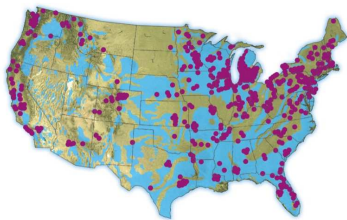
Superfund Sites

- Total costs for hazardous waste cleanup in the U.S. are estimated between \$370 billion and \$1.7 trillion of taxpayer money.
- Most sites are old industrial facilities and chemical manufacturing plants around the Great Lakes and Gulf Coast. Mining areas and old dumps are also prime sources of toxic waste.
- Studies of Superfund sites reveal minorities tend to be over-represented in these neighborhoods.

Map of Hazardous Waste Sites

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- Hazardous waste site
- Aquifers



Brownfield Liabilities and Opportunities

- **Brownfields** - contaminated properties that have been abandoned or are not being used up to potential because of pollution concerns
 - Up to one-third of all commercial industrial sites in urban core of many big cities fall into this category.
 - In many cases, property owners complain that unreasonably high purity levels are demanded in remediation.
 - Providing liability insurance against future cleanup costs is beneficial in reusing brownfields.

Hazardous Waste Management Options

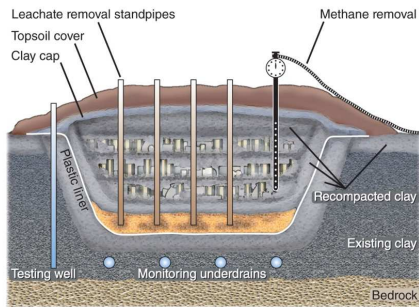
- **Produce Less Waste**
 - Avoid creating wastes in the first place
 - Recycle and Reuse - what is waste to one industry is raw product for another
 - Use less-toxic alternative
- **Convert to Less Hazardous Substances**
 - Physical Treatment (Isolation)
 - Incineration
 - Chemical Processing (Transformation to non-toxic substances)
 - Bioremediation (Microorganisms detoxify)

Hazardous Waste Management Options

- **Store Permanently**
 - **Retrievable Storage** - in containers in salt mines or caverns
 - Can be inspected and periodically retrieved if necessary
 - **Secure Landfills**
 - Modern, complex landfills with multiple liners and other impervious layers, covered by a cap. Leachate is processed, and monitoring sees that no toxins escape.

Toxic Waste Secure Landfill

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Toxic Waste Storage

- **Transportation of hazardous wastes to disposal sites risks accidents**
 - Of particular concern in densely packed urban corridors
- **Another worry is who will bear financial responsibility for abandoned waste sites.**
- **We may need new institutions for perpetual care of toxic wastes and nuclear wastes.**
