Solid & Hazardous Wastes

Solid waste—any unwanted or discarded material that is not a liquid or gas

* US generates about 33% of all solid waste with only 4.5% of the world’s population
* 98.5% of solid wastes come from mining, oil & natural gas production, agriculture, & industrial activities to produce consumer goods
* 1.5% is municipal solid waste
  + - Average annual production of 440 billion pounds
    - Averages 1600 pounds per person in US
    - Fate of municipal solid wastes:
      * Dumped into landfills—55%
      * Recycled or composted—30%
      * Burned in incinerators—15%
* EPA ranking of the most environmentally sound strategies for MSW
  + - Source reduction (including reuse and dematerialization)
    - Recycling and composting
    - Disposal in combustion facilities and landfills

Hazardous waste—legally defined as any discarded solid or liquid material that:

* contains one or more of 39 toxic, carcinogenic, mutagenic, or teratogenic compounds at levels that exceed established limits
* flammability (catches fire easily)
* reactivity (is reactive or unstable enough to explode or release toxic fumes)
* corrosiveness (is capable of corroding metal containers such as tanks, drums, & barrels)
* Does NOT include (excluded from regulation)
  + - Radioactive wastes
    - Household disposal of hazardous compounds
    - Mining wastes
    - Hazardous waste laws do not regulate 95% of the US hazardous wastes

Dealing with Solid & Hazardous Wastes

* Waste management
  + - Attempts to reduce environmental harm of producing wastes
      * Burying wastes
      * Burning wastes
      * Shipping wastes to other places (Case Study – Khian Sea, led to the Basel Convention in 1989)
* Time required for waste material to decompose
  + - Organic wastes—1-2 weeks
    - Paper—10-30 days
    - Wood—10-15 years
    - Tin, aluminum, & metal cans—100-500 years
    - Plastics—1 million years
* Preventing pollution & wastes – Low Waste Approach
  + - Reduce waste & pollution
    - Reuse as many things as possible
    - Recycle and compost as much waste as possible
    - Chemically or biologically treat or incinerate waste that cannot be reduced, reused, or recycled
    - Bury what is left in state-of-the-art landfills
* Reducing wastes
  + - Decreasing consumption
    - Doing more with less (redesigning manufacturing processes to use less materials and energy)
    - Developing products that are easy to reuse, manufacture, and recycle
    - Designing products to last longer (tires)
    - Eliminating or reducing unnecessary packaging
    - Ecoindustry—use of resource exchange webs joining different industries in recycling wastes & products
    - Using trash taxes
      * Pay-as-you-throw system
* Reuse—form of waste reduction that:
  + - Extends resource supplies
    - Keeps high-quality matter resources from being reduced to low-matter-quality waste
    - Reduces energy use & pollution
    - Most efficient method of reclaiming materials
    - Refillable glass beverage bottles (reused up to 15 times)
      * Only about 7% of the beer and soft drink market
    - Shift from using disposable diapers to cloth diapers
* Recycling—
  + - Primary (closed-loop) recycling—wastes discarded by consumers (post-consumer wastes) are recycled to produce new products of the same type
      * Reduces use of virgin resources & saves energy
    - Secondary (open-loop) recycling—waste materials are converted into different and usually lower-quality products
    - Reduces energy requirements to produce product
    - Recycling aluminum cuts energy use by 95%
    - Materials-recovery Facilities—collection of mixed urban waste and machine separation to recover valuable materials for sale to manufacturers as raw materials
      * Can produce electricty
      * Expensive
      * Can emit toxic air pollution (addressed by wet scrubbers, electrostatic precipitators, sorbants)
      * Produces toxic ashes after incineration of leftover trash
      * Requires a high input of garbage to be financially successful
    - Aluminum
      * US gets 60% of its aluminum from virgin ore
      * In 1999, 74% of all aluminum cans were recycled in the US
    - Plastics
      * Various types of polymer molecules made by chemically linking monomers of petrochemicals produced from oil and natural gas
      * Accounts for 22% of all MSW by volume
      * Burning plastics releases dioxins (carcinogenic & toxic by-product of plastic manufacturing)
      * Biodegradable & photodegradable plastics are made to break down into smaller pieces
        + Affects more organisms in different trophic levels
      * Problems in recycling plastics
        + Plastics are difficult to isolate from other wastes
        + Price of oil is so low that the cost of virgin plastic resins is about 40% lower than that of recycled resins (has more become more economical as oil prices rise and as oil becomes more scarce)

Incineration of Solid Wastes

* Reduces impact on landfills, but expensive to build
* Reduces volume of wastes by up to 80-90%
* Kills pathogens
* Leads to increased air pollution (lead, mercury, cadmium, sulfur oxides, etc.)

Sanitary Landfills—solid wastes are spread out in thin layers, compacted, & covered daily with clean soil

* Lined with clay and plastic before being filled with garbage
* Second impermeable layer collects leachate (rainwater contaminated as it percolates through the solid wastes)
* Leachate is pumped from bottom of landfill and sent to sewage treatment plants
* When full, landfills are covered with clay, sand, gravel, and topsoil to prevent water from seeping in
* Network of pipes to collect landfill gas (methane & carbon dioxide)
* 86% of all older landfills have contaminated groundwater

Detoxification of Hazardous Wastes

* Bioremediation—microorganisms & enzymes are used to destroy toxic or hazardous substances or convert them to harmless compounds
  + - Exxon Valdez – used microbes to help clean –up shoreline contamination
    - Works well for organic wastes (pesticides, gasoline, diesel fuel, PCBs)
    - Does not work well for toxic metals
* Phytoremediation—using natural or genetically engineered plants to filter and remove contaminants
  + - * Sunflowers remove 95% of lead contamination in soils
      * Canola plants soak up selenium from soil
      * Advantages & disadvantages of phytoremediation
        + Inexpensive
        + Reduces erosion
        + Aesthetically pleasing
        + Can reduce the amount of material dumped into landfills
        + Slow and effective only at depths reached by roots
        + Contaminated plants may be eaten by wildlife
        + Plant material may have to be disposed of in a hazardous waste landfill

Disposal of Hazardous Wastes

* Deep-well disposal—liquid hazardous wastes are pumped under pressure through a pipe into dry, porous geologic formations far beneath aquifers
* Surface impoundments—excavated depressions, ponds, or lagoons into which liquid hazardous wastes are drained and stored
  + - EPA estimates that 90% of all surface impoundments threaten groundwater
* Secure hazardous-waste landfills
  + - Storage in drums and carefully buried
    - NIMBY consequences
    - Aboveground buildings—built of reinforced concrete & create a negative pressure to prevent the release of toxic gases

Toxicology—measure of how harmful a substance is

* Potential harm is dependent on
  + - Dosage
    - Bioaccumulation—some molecules are absorbed & stored in specific organs or tissues at levels higher than normally would be expected
    - Biomagnification—levels of some toxins in the environment are magnified as they pass through a food web
      * DDT, PCBs, & some radioactive isotopes
    - Chemical interactions that can decrease or multiply the effects of a toxin
      * Antagonistic interaction—reduce the harmful response
        + Vitamins A & E interact to reduce body’s response to carcinogens
      * Synergistic interaction—multiplies harmful effects
        + Asbestos increase chances of lung cancer, but asbestos workers who smoke increase chances of lung cancer 400x
* Poison—chemical that has an LD50 of 50 mg or less per kg of body weight
  + - LD50—median lethal dose
      * The amount of chemical that in one dose that kills exactly 50% of the animals in a test population within a 14 day period
* Toxicity Testing
  + - Dose-response curves—shows the effects of various dosages of a toxic agent on a group of test organisms
      * X-axis plot concentration of toxin & y-axis plots response
      * Usually follows an S-shaped curve
    - Epidemiology—study of the patterns of disease or other harmful effects from toxic exposure within defined groups of people to figure out why some people get sick and other do not