

Chapter 15: Environmental Health, Pollution and Toxicology



- I. Toxicology and Chemical Hazards : The US is the worst offender!!!!
 - A. Background info.
 - toxicology—the study of the harmful effects of substances on humans or animals and the environment
 - Department of Health and Human Services
 - develops and carries out tests to predict whether a chemical will cause harm to humans
- IRIS: Integrated Risk Information System
www.epa.gov/iris/intro.htm

Concept of Dose and Response

- Five centuries ago, the physician and alchemist Paracelsus wrote that “everything is poisonous, yet nothing is poisonous.”
- The effect of a chemical on an individual depends on the dose.
 - Dose response
 - Dose dependency can be represented by a generalized dose response curve.
 - Doses that are beneficial, harmful, or lethal may differ widely for different organisms and are difficult to characterize.
- For Example
 - Selenium required in small amounts by living things
 - May be toxic in high concentrations

Dose-Response Curve

- Dose at which 50% of the population dies
 - Lethal dose 50, LD-50
 - Poison is any substance that has an LD 50 less that 50mg/kg of body mass
 - Toxic substances have a low LD50
- The ED-50 (effective dose 50%) is the dose that causes an effect in 50% of the population of observed subjects.
 - E.g. ED-50 of aspirin would be the dose that relieves headaches in 50% of the people.
- The TD-50 (toxic dose 50%) is defined as the dose that is toxic to 50% of the population.
 - Often used to indicate responses such as reduced enzyme activity, decreased reproductive success, or onset of specific symptoms.

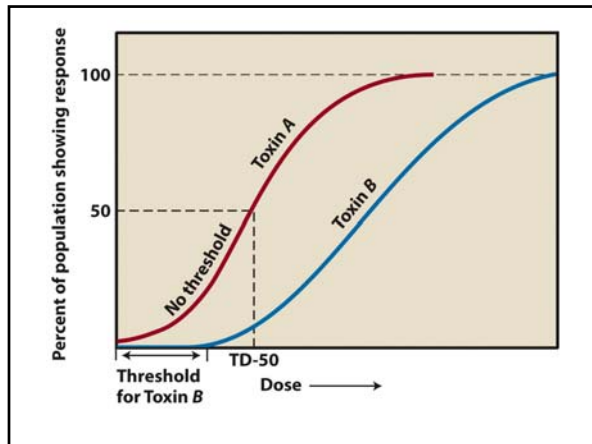
Table 15.4 Approximate LD-50 Values (for Rodents) for Selected Agents

Agent	LD-50(mg/kg) ^a
Sodium chloride (table salt)	4,000
Ferrous sulfate (to treat anemia)	1,520
2,4-D (a weed killer)	368
DDT (an insecticide)	135
Caffeine (in coffee)	127
Nicotine (in tobacco)	24
Strychnine sulfate (used to kill certain pests)	3
Botulinum toxin (in spoiled food)	0.00001

^aMilligrams per kilogram of body mass (termed mass weight, although it really isn't a weight) administered by mouth to rodents. Rodents are commonly used in such evaluations, in part because they are mammals (as we are), are small, have a short life expectancy, and their biology is well known.
 Source: H. B. Schiefer, D. C. Irvine, and S. C. Buzik, *Understanding Toxicology* (New York: CRC Press, 1997).

Threshold effects

- Threshold is a level below which no effect occurs and above which effects begin to occur.
 - If a threshold exists, then a concentration below the threshold is safe.
 - If there is no threshold dose, then even the smallest amount has some negative toxic effect.
- A problem in evaluating thresholds for toxic pollutants is that it is difficult to account for synergistic effects.



• Tolerance

- The ability to resist or withstand stress resulting from exposure to a pollutant or harmful condition.
 - Result from behavioral, physiological, or genetic adaptation.
- Behavioral tolerance- change in behavior
 - Learning to avoid traps
- Physiological tolerance- the body of an individual adjusts to tolerate a higher level of pollutant.
 - Many mechanisms including detoxification
 - the toxic chemical is converted to a nontoxic form
 - Internal transport of the toxin to a part of the body where it is not harmful, such as fat cells.
- Genetic tolerance- (adaptation) when some individuals in a population are naturally more resistant to a toxin than others.
 - Strains of mosquitoes resistance to DDT
 - Antibiotic resistance

Acute and Chronic Effects

- Toxicity can be effected by dose, length of exposure, size of organism, and sensitivity to substance
- Acute effect is one that occurs soon after exposure.
 - Usually to large amounts of a pollutant
 - Ex: Instant swelling from a bug bite
- Chronic effect takes place over a long period
 - Often as a result of exposure to low levels of pollutant
 - Long lasting and permanent
 - Exiling cancer due to smoking

threshold

- threshold—the dose or exposure level below which a significant adverse effect is not expected
 - threshold level—time-weighted average pollutant concentration values, exposure beyond which is likely to adversely affect human health
- C. The Nature of Chemical Hazards: HAZMATs
 - 1) HAZMAT—hazardous material
 - 2) properties of classification
 - ignitability(flammable)—catch fire easily
 - corrosive—eat away skin, storage tanks, or equipment
 - reactivity—chemically unstable; potentially explosive or fume-producing
 - toxicity—poisonous when consumed
 - 3) nine classifications: explosives, gases, flammable liquids, flammable solids, oxidizers, poisons or infectious agents, radioactive, corrosive, miscellaneous

Sources:

- Main types:
 - Point source, fugitive source and area source
 - Methods
 - Accidental
 - Mining
 - Refining
 - Deliberate (fertilizer)
 - Chemical by product
 - Evaporative volatile chemicals
 - Particulate from combustion
 - Landfill leachate
 - Business(dry cleaning, gas station)
 - Household
 - In the US
 - The top three toxic waste-producing industries are chemical, mining, and military

Household Hazards

- 1) *Automotive products*
 - Examples: gasoline, motor oil, antifreeze, windshield wiper fluid, car wax and cleaners, lead-acid batteries, brake fluid, transmission fluid
- 2) *Home improvement products*
 - Examples: paint, varnish, stain, paint thinner, paint stripper, caulk, adhesives
- 3) *Pesticides*
 - Examples: insecticide and insect repellent, weed killer, rat and mouse poison, pet spray and dip, flea collars, mothballs, disinfectant, wood preservative
- 4) *Household cleaners*
 - Examples: furniture polish and wax, drain opener, oven cleaner, tub and tile cleaner, toilet bowl cleaner, spot remover, bleach, ammonia
- 5) *Other*
 - Examples: household batteries, cosmetics, pool chemicals, shoe polish, lighter fluid, prescription medicines, arts and crafts materials

Dealing with toxins

- Integrated management approach suggested by the US National academy of science
 - Produce less hazardous material
 - Reuse, recycle
 - Safe disposal
- Clean It Up Activity

Two main ways to clean it up

Detoxification:

- Incineration: Burning, creates air pollution and hazardous ash
- Decomposition
- Charcoal filtration: Physical detox of waste
- Cyclodextrin: Chemical method of detox
- Bioremediation (bacteria) phytoremediation (Plants)
- Long Term Land Disposal/storage:
 - Deep well/underground injection, (Best for radioactive) Injected below aquifers
 - subsurface impoundment: Ponds, pits or lagoons that are lined for storage of wastes, Leakage can occur due to leaking liners or disasters (Bay of Pigs)
 - Under Salt formations: Absence of water flow prevents dissolving and spreading
 - secure landfills, (leaks can contaminate groundwater)
 - midnight dumping

Disease

- Disease is often due to an imbalance resulting from poor adjustment between the individual and the environment.
- Seldom have a one-cause- one-effect relationship w/ the environment
- Depends on several factors
 - Physical environment
 - Biological environment
 - Lifestyle
- Chances of experiencing serious environmental health problems and disease depends on
 - The water we drink
 - The air we breathe
 - The soil we grow crops in
 - The rocks we build our homes on
- Natural processes can release harmful materials into the soil, water or air.
- Lake Nyos in Cameroon, Africa
 - Experienced sudden release of carbon dioxide
 - Killed 1,800 people in near by town



Terminology

- Toxic refers to materials (pollutants) that are poisonous to people and other living things.
 - Toxicology is the science that studies chemicals that are known to be or could be toxic.
- Carcinogen: increases the risk of cancer (Most feared and regulated toxins in our society)
- Teratogen: Interferes with embryo development
- Mutagen: Damage DNA
- Neurotoxin: Interferes with neurological function
- Allergen: Harmless substance that causes immune response
- Endocrine disruptors: disrupts growth and development (hormones)

Terminology

- Synergism
 - The interaction of different substances resulting in a total effect greater than the sum of the effects of the separate substances.
 - E.g. NO_x + Ozone + VOC = Photochemical Smog
- Pollutants introduced into the environment
 - Point sources, such as smokestacks, pipes discharging into waterways, stream entering the ocean, or accidental spills.
 - Area sources, (non point sources), which are more diffused over the land and include urban and agricultural runoff and mobile sources such as automobile exhaust.

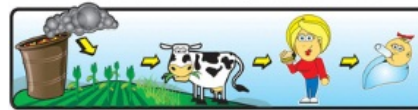
Types of Toxins

- Infectious agents
- Organic Compounds
 - POP
 - HAA
- Heavy Metals
- Air Pollution
- Radiation
- Thermal
- Particulates
- Electromagnetic Fields
- Noise
- Voluntary

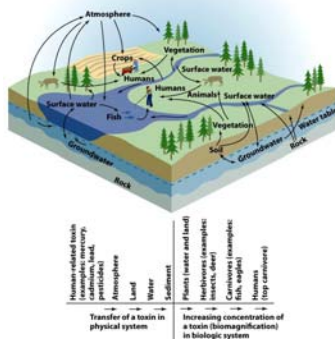
Toxic Pathways

- Chemical elements can become concentrated
- Bioaccumulation: increase in concentration of a pollutant from the environment to the first organism in the food chain
- Biomagnification- increase in concentration of a substance in living tissue as it moves through the food chain.
 - E.g. Cadmium, mercury
- Toxins need to metabolize and usually accumulate in fat

Bioaccumulation & Biomagnification of Dioxins



Bioaccumulation & Biomagnification of Dioxins



Infectious Agents

- Infectious disease
 - Spread from the interactions between individuals and food, water, air or soil.
 - Can travel globally via airplanes
 - New diseases emerging and previous ones reemerging
 - Diseases that can be controlled by manipulating the environment
 - classified as environmental health concerns

Environmentally Transmitted Infectious Diseases

- Legionellosis
 - Occurs where air-conditioning systems have been contaminated by disease-causing organisms.
- Giardiasis
 - a protozoan infection of the small intestine spread via food, water, or person-to-person contact.
- Salmonella
 - a food-poisoning bacterial infection spread via water or food.
- Malaria
 - a protozoan infection transmitted by mosquitoes.
- Lyme disease
 - Transmitted by ticks.
- Cryptosporidiosis
 - a protozoan infection transmitted via water or person-to-person contact.
- Anthrax
 - Bacterial infection spread by terrorist activity.

Toxic Heavy Metals

- The major heavy metals that pose health hazards to people and ecosystems include:
 - mercury, lead, cadmium, nickel, gold, platinum, silver, bismuth, arsenic, selenium, vanadium, chromium, and thallium.
- Each may be found in soil and water not contaminated by humans.
- Often have direct physiological effects.
 - Stored and incorporated in living tissue
 - Fatty body tissue
 - Content in our bodies referred to as body burden.

Organic Compounds

- Organic compounds
 - compounds of carbon produced naturally by living organisms or synthetically by human industrial practices.
- Synthetic organic compounds
 - Used in industrial processes, pest control, pharmaceuticals, and food additives.
 - Over 20 million

Persistent Organic Pollutants

- POPs may produce a hazard for decades or hundreds of years.
 - First produced when their harm was not known
 - Now banned or restricted
- POPs have several properties that define them:
 - They have a carbon-based molecular structure, often containing highly reactive chlorine.
 - Most are synthetic chemicals.
 - They do not easily break down in the environment.
 - They are polluting and toxic.
 - They are soluble in fat and likely to accumulate in living tissue.
 - They occur in forms that allow them to be transported by wind, water, and sediments for long distances.

Table 15.1 Selected Common Persistent Organic Pollutants (POPs)

Chemical	Example of Use
Aldrin ^a	Insecticide
Atrazine ^b	Herbicide
DDT ^a	Insecticide
Dieldrin ^a	Insecticide
Endrin ^c	Insecticide
PCBs ^d	Liquid insulators in electric transformers
Dioxins	By-product of herbicide production

Source: Data in part from Anne Platt McGinn, "Phasing Out Persistent Organic Pollutants," in Lester R. Brown et al., *State of the World 2000* (New York: Norton, 2000).

^a Banned in the United States and many other countries.

^b Degrades in the environment. It is persistent when reapplied often.

^d Restricted or banned in many countries.

Hormonally Active Agents

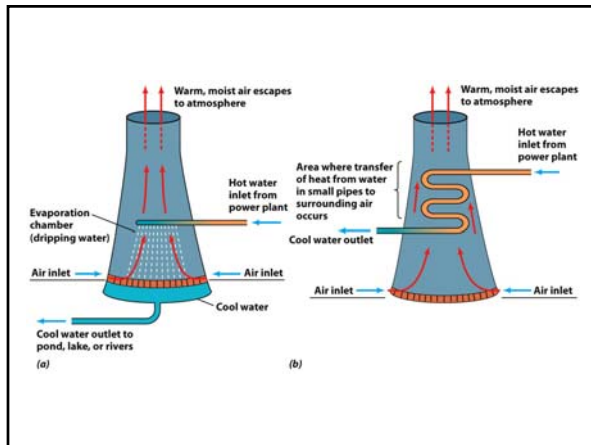
- HAA are also POPs.
- Have potential to cause developmental and reproductive abnormalities in animals, including humans.
 - Include a wide variety of chemicals, herbicides, pesticides, phthalates, and PCBs
- Evidence in support of hypothesis
 - Alligator populations in Florida exposed to DDT have genital abnormalities, low egg production and reduced penis size.
 - Other Examples: thinning of eggshells of birds, decline in populations of various animals and birds, reduced viability of offspring, and changes in sexual behavior.
- In humans
 - HAAs may be linked to breast cancer
 - PCBs and neurological behavior
 - Phthalates and endocrine and hormone disruption

Endocrine System

- One of two main systems that regulate and control growth, development and reproduction.
- Composed of a group of hormone secreting glands
 - Thyroid, pancreas, pituitary, ovaries and testes.
 - Hormones transported by blood stream, act as chemical messengers.
- The National Academy of Sciences
 - recommends that there should be continued monitoring of wildlife and human populations for abnormal development and reproduction.

Thermal Pollution

- Occurs when heat released into water or air produces undesirable effects.
 - Also called heat pollution
 - Sudden acute event or long term, chronic release
 - Heated water released into rivers changes temp and dissolved oxygen content
 - Thereby changing river's species composition
- Heating river water changes natural conditions and disturbs the ecosystem
 - Fish spawning cycles may be disrupted
 - Fish may have heightened susceptibility to disease.
 - Physical stress on fish
 - Easier prey
 - Change in type and availability of food
- Solutions to chronic thermal heating
 - Release of heat into air in cooling towers
 - Artificial lagoons
 - Used to heat buildings



Voluntary Exposure

- Sometimes referred to as exposure to personal pollutants.
 - Tobacco
 - 30% of cancers tied to smoking
 - Carcinogen, one of the most deadly indoor pollutant
 - Alcohol and other drugs
 - ½ of all deaths in automobiles accidents tied to alcohol use by drivers
 - Violent crimes, overdoses, chronic alcoholism

Chemical	Source	Type	Effect
Lead	Paint, gasoline	Neurotoxin	Impaired learning, nervous disorders, death
Mercury	Coal Burning, fish	Neurotoxin	Damages brain, kidneys, liver, immune
Arsenic	Mining, groundwater	Carcinogen	Cancer
Asbestos	Building material	Carcinogen	Impaired breathing, lung cancer
PCB	Industry, plastic	Carcinogen	Cancer; impaired learning, liver damage
Radon	Soil, water	Carcinogen	Lung Cancer
Vinyl Chloride	Industry, water from pipes	Carcinogen	Cancer
Alcohol	Beverages	Teratogen	Reduced fetal growth, brain and nervous damage
Atrazine	Herbicide	Endocrine Disruptor	Feminization of males, low sperm count
DDT	Pesticide	Endocrine Disruptor	Feminization of males, thin eggshells of birds
Phthalates	Plastics and cosmetics	Endocrine Disruptor	Feminization of males

Air Pollution

- Criteria pollutants: CO, Ozone, SO₂, NO_x, Particulates, lead
- SO₂: produced by burning coal, acid rain
- Industrial Smog: Particulates and SO₂
- Photochemical Smog: NO_x+ Ozone+ VOC
 - UV radiation is required for ozone formation

Basic Economic Terms for APES

- GDP: Useful tool to compare economic outputs of nations
- GPI: (genuine progress indicator) subtracts harmful env. costs and adds benefits not calculated in GDP
- HPI: (Life satisfaction x ave. life span)/ecofootprint (Highest in Central America)
- Eco-Labeling: to show that their manufacture conforms to recognized environmental standards
- Comand and Control Laws: regulations that set fixed limits on resource use or pollution emmissions and punishments
- Cap-and-trade: Tradeable pollution permits or resource use permits
- Incentive based regulations: market forces used to encourage resource conservation and waste reduction

Green or Eco Taxes

- Are excise taxes on environmental pollutants or on goods whose use produces such pollutants.
 - A pure environmental tax aims to ensure that polluters face the true cost of their activities by charging them for the damages caused to others.
 - Carbon Tax
 - Lowering taxes on profit when using green technology
 - Lowering taxes on wages when using green technology
 - Fishing and Hunting Licences

Risk Analysis

- Two componenets:
 - Risk Assessment: The process of determining potential adverse environmental health effects to people exposed to pollutants and potentially toxic materials.
 - Risk Management
- Environmental risk analysis compares the risk of a situation to its related benefits

Risk Assessment

- Greatest health risk is poverty in terms of reduced life span
- In the US, the strongest determinant of exposure to environmental hazards is race
- EPA concluded that high risk environmental problems would be
 - Global climate change
 - Ozone depletion
 - Habitat loss
 - Species extinction

Dirty Places....

- Superfund: Initially financed by taxes on producers of toxic waste, these monies finance the emergency cleanup of serious sites that poise immediate threat
- Brownfields: contaminated, cleaned to a certain level then abandoned (pollution still exists)
- Toxic release inventory: Sites that are required to report the release of about 300 toxic materials to provide citizens of risk
- National Priority List (NPL) sites: sites leaking carcinogens, teratogens, or mutagens funded by the Superfund