Chemical Hazards to Human Health

APES
CHAPTER 17
Evaluating Chemical Hazards

Humans are constantly exposed to invisible chemicals.

Chemicals can enter living organisms through inhalation, ingestion, or absorption through skin.

**Toxicology** is the study of the detrimental effects these chemicals have on both humans and wildlife.

**Toxicologists** gather data from various sources to determine effects of a particular chemical.

**Toxicity** is the ability of a chemical to cause harm to a living organism.
Persistence

Some chemicals will last for long periods of time in the environment because they are not easily degraded or broken down.

These chemicals are persistent.
Solubility

Chemicals that are fat soluble easily accumulate in the tissue of living organisms.

Chemicals that are water soluble will be dissolved easily in bodies of water.
Biomagnification

Certain compounds that accumulate in body tissues can be passed from one organism to another through the food chain.

Organisms on higher trophic levels, like secondary and tertiary consumers, will have the highest concentration of these materials in their bodies.
Biomagnification
Biomagnification

Accumulation of mercury in the food chain

Mercury level (EPA advice for consumption):
- Eat only a few times per month
- Eat a few times per week
- Unlimited
Mercury: From Source to Seafood
Biomagnification

Some of our well-known toxic chemicals belong to a group of synthetic organic compounds known as chlorinated hydrocarbons.

These chemicals are harmful because they persist for long periods of time in the environment, are fat soluble, and accumulate in organisms at higher trophic levels (biomagnification).

Examples of these compounds include DDT, PCBs, and vinyl chloride.
Dose-Response Curve

When defining a harmful level, toxicologists must determine the average dose to which an organism is generally exposed and the effects of increasing that exposure.

Toxicity of a substance can vary with the dose to which an organism is exposed and may have a threshold level below which no effects can be discerned.

By plotting an organism’s response to a given chemical versus the dose received, one can generate a graph known as a dose-response curve.
Dose-Response Curve

The response is any negative health effect elicited from that particular material.

An acute effect is an immediate response to exposure.

A chronic effect can occur from a single dose or long-term exposure to smaller doses of a toxin.

A chronic effect causes longer-lasting or permanent damage to the body, such as liver and kidney disease or even cancer.

By examining dose-response curves, toxicologists can determine what dose would be required to be lethal for 50% of the test population.

This is known as the median lethal dose or LD50.
Dose-Response Curve LD50
Dose-Response Curve

If the response or effect begins at zero and increases continuously with a dosage, then it is referred to as a non-threshold dose-response model.

In contrast, a threshold dose-response model shows that harmful effects do not occur until after the dose exceeds a threshold level.
Threshold & Non-Threshold Dose-Response Curves
Problems With Toxicity Testing

There are many issues with producing accurate pictures of how chemical toxins really impact living organisms.

Due to **genetic variability**, each individual can exhibit a different response to a given level or type of chemical exposure.

Also, we typically test only for the response to one chemical at a time.

However, living organisms are exposed to a wide variety of toxins at once, and understanding the **synergistic effect** or combination of chemical compounds is almost impossible.
Types of Chemical Hazards

**Toxic chemicals** may cause short-term or permanent damage to humans or animals.

There are 3 main categories of toxins: **carcinogens**, **mutagens**, and **teratogens**.

Many chemicals can fall into more than one of these main categories.
Carcinogen

These compounds cause or promote various types of cancer in the human body.

Cancerous cells, also known as malignant cells, multiply uncontrollably and create tumors that damage body tissue and may cause death.

Examples of carcinogens include benzene, poly-aromatic hydrocarbons found in tobacco smoke, formaldehyde, dioxins, and PCBs.
Mutagen

This category of chemical hazard promotes mutations or changes in DNA.

These changes may also cause cancers or be passed on to future generations.
Teratogen

These are chemical hazards that cause **birth defects** to a fetus or embryo.

Examples of **teratogens** include heavy metals, formaldehyde, ethyl alcohol, PCBs, and phthalates.
Exposure to Chemical Toxins

Exposure to chemical toxins often causes damage to many of the body’s systems.

The immune system is often weakened by exposure to chemical toxins.

This leaves the body more vulnerable to attack from pathogenic bacteria, viruses, and parasites.
Exposure to Chemical Toxins

Chemical toxins can also cause devastating affects on the nervous system.

Toxins that cause damage to the brain, nerves, or spinal cord are known as neurotoxins.

Some examples of neurotoxins include methylmercury, PCBs, and lead.
Exposure to Chemical Toxins

Scientists have provided evidence that chemical toxins can disrupt the endocrine system in both humans and wildlife.

Some chemical toxins, known as hormonally active agents (HAA), are endocrine disruptors because they either mimic estrogen (female sex hormone) or block androgens (male sex hormones) from binding to their appropriate receptor sites in the cell.

These endocrine disruptors cause damage during sexual development.

Scientists are also concerned that these toxins may cause increased cases of testicular cancer in males and breast cancer in females.

Examples include DDT, PCBs, and phthalates.
Case Study: Bhopal, India

In 1984, the world’s most horrific industrial accident happened at a pesticide manufacturing plant in Bhopal, India.

An explosion in an underground storage tank released deadly hydrogen cyanide gas into the atmosphere.

Over 50,000 people suffered permanent injuries including blindness, lung damage, and neurological disorders.

It is estimated that between 15,000 and 20,000 people died.
Legislation That Regulates Chemical Toxins

**Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)**

Gives the EPA the authority to regulate the sale, packaging, distribution, and disposal of pesticides.

The EPA also has the right to suspend the use of pesticides that are found to pose unreasonable risks to humans or wildlife.
Legislation That Regulates Chemical Toxins

**Federal Food, Drug, and Cosmetic Act**

Allows the EPA to set tolerance levels for pesticide residue on food for human consumption as well as on feed meant for livestock consumption.
Legislation That Regulates Chemical Toxins

**Food Quality Protection Act of 1996**

This law amended the two aforementioned laws. It outlines more requirements for assessing tolerance levels for pesticides. It also provides extra funding for the protection of infants and children.
Legislation That Regulates Chemical Toxins

**Emergency Planning and Community Right-to-Know Act**

Commonly known as the “Right-to-Know Act,” this legislation requires federal, state, and local governments to improve public knowledge and access to information regarding toxic chemicals.
PCBs (Polychlorinated Biphenyl)

**Sources**

Used as electrical insulators, fire retardant materials, pesticides, and as adhesives (banned in the U.S.).

**Health or Wildlife Health Impact**

Neurotoxin causing brain damage in fetuses.

Endocrine disruptor causing reproductive cancers.
DDT (Dichlorodiphenyltrichloroethane)

**Sources**
A commonly used pesticide in the U.S. prior to banning it in 1972.
Still used in developing countries to control malaria and pests.

**Human or Wildlife Health Impact**
Biomagnifies in the food chain of ecosystems.
Causes reproductive damages and cancers in avian (bird) populations.
Phthalates

Sources

Group of chemicals used in the production of plastics.
Used as solvents in many products such as vinyl flooring, adhesives, detergents, and some personal care products like soap and shampoo.

Human or Wildlife Health Impact

Causes reproductive damage and cancers.
Atrazine

Sources

One of the most widely used pesticides in the U.S.

Herbicide primarily used to control weed populations in the Midwest.

Human or Wildlife Health Impact

This pesticide is currently being monitored by the EPA to determine if it is linked to endocrine cancers in humans and amphibians.
Bisphenol A (BPA)

Sources
A chemical building block for plastic consumer goods such as water bottles, food containers, and microwaveable dishes.

Human or Wildlife Health Impact
Some evidence suggests exposure can lead to neurological damage and reproductive cancers.
Heavy Metals: Hg, As, Pb, Cd

Sources
Heavy metal pollution is often generated from smelting metals and incineration of municipal waste.
Elemental mercury is used in batteries and fluorescent lights.
Inorganic mercury released from coal burning is converted to toxic methylmercury by bacteria.

Human and Wildlife Health Impact
Heavy metals often biomagnify in the food chain.
Cause neurological damage especially in fetuses.
Can be carcinogenic.
Benzene

Sources

Emissions from burning coal and oil and tobacco smoke.

Human or Wildlife Health Impact

Short-term exposure causes dizziness and nausea.

Long-term exposure causes damage to the liver and reproductive system, cancer, and birth defects.
Vinyl Chloride

Sources
Is a precursor to making polyvinyl chloride (PVC), which is commonly used in building materials and many consumer products.

Human or Wildlife Health Impact
Causes cancers, especially liver cancers.
Can do damage to the central nervous system.
Is known to cause birth defects.
Asbestos

Sources
A naturally occurring silicate mineral formerly used in insulation materials for its fire-retarding properties.

Human or Wildlife Health Impact
Known to cause cancer.
Dioxins

Sources
A class of chemical compounds formed during incineration of waste materials and also in the manufacturing process of some herbicides.

Human or Wildlife Impact
Accumulate in fatty tissue of organisms (bioaccumulation).
Carcinogen.
Causes reproductive damage.
Cultural and Lifestyle Hazards

The greatest risk that people in developing countries face today is poverty.

Poverty increases the chance of being exposed to infectious disease from living in crowded conditions with inadequate availability of sanitary conditions including clean drinking water.

People in impoverished conditions also suffer from malnutrition, which increases their susceptibility to disease and death.
Cultural and Lifestyle Hazards

In developed nations, people can choose to reduce their risk of death by avoiding smoking, improving eating habits, getting adequate exercise, and limiting alcohol intake. Many deaths from cardiovascular disease and certain types of cancers could be prevented with modifications to lifestyle choices.
Health Impacts of Pollution
https://www.youtube.com/watch?v=VcDjyxanOyk