Essentials of Environmental Health

Second Edition

Robert H. Friis
Chapter 7

Pesticides and Other Organic Chemicals
By the end of this chapter the reader will be able to:

• List common substances that are included in the organophosphate group
• Name three commonly used insecticides and one commonly used herbicide
• Discuss the health effects of exposure to pesticides
• Name one chemical used in the manufacture of plastics
• Describe the potential health effects of exposure to household cleaning products
Advantages of Hazardous Chemicals

• Essential to the functioning of modern society
• 15,000 chemicals made and used in high volume in the United States for manufacturing clothing, phones, computers, cars, building materials, rugs and other furnishings
Disadvantages of Hazardous Chemicals

• Implicated as human health hazards, for example, in the etiology of cancer and adverse birth outcomes

• Silent Spring, written by Rachel Carson in 1962, is credited with sensitizing the public to the potential hazards of chemicals that were being disseminated into the environment.
Aromatic Compound

- Organic molecule that contains a benzene ring, for example, benzene and toluene
Hydrocarbon

• An organic compound (as acetylene, benzene, or butane) containing only carbon and hydrogen and often occurring in petroleum, natural gas, coal, and bitumens.
Organic Chemical

- Naturally occurring (animal or plant-produced or synthetic) substances containing carbon, hydrogen, nitrogen, and oxygen.
- Ordinary table sugar is an example of an organic chemical.
Persistent Organic Pollutants (POPs)

• Toxic chemicals that adversely affect human health and the environment around the world.
• Because they can be transported by wind and water, most POPs can and do affect people and wildlife far from where they are used and released.
• An example is the pesticide DDT.
Polycyclic Aromatic Hydrocarbons (PAHs)

• A group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat.
Volatile Organic Compounds (VOCs)

- Organic compounds that evaporate readily into the air.
- VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.
Pesticide

• “any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pests. Pests can be insects, rodents, weeds, and a host of other unwanted organisms.”
Insecticide

• A pesticide compound specifically used to kill or prevent the growth of insects.
Herbicide

- A chemical pesticide designed to control or destroy plants, weeds, or grasses
Fungicide

• A pesticide that is used to control, deter, or destroy fungi
Nematocide

- A chemical agent that is destructive to nematodes
Rodenticide

- A chemical or agent used to destroy rats or other rodent pests, or to prevent them from damaging food, crops, etc.
Four Major Classes of Pesticides and Insecticides Derived from Organic Chemicals

- Organophosphates (OPs)
- Organocarbamates (also called carbamates)
- Organochlorides (also known as organochlorines)
- Pyrethroids (from the class of pyrethrins)
Organophosphate Pesticides
(Anticholinesterases)

• Can be used to control a wide range of insects, thus eliminating the need for multiple applications of different pesticides
• Have not been weakened by the resistance of insects
• Tend not to persist in the environment
• Frequent cause of fatal poisonings
Effects of Organophosphate Poisoning

- **Acute effects:** Anticholinesterase activity happens soon after exposure and causes impairment of the neural impulse transfer mechanism.

- **Long-term effects:** may include a condition known as organophosphate-induced delayed polyneuropathy, which is manifested by numbness, loss of sensory abilities, and weakness.
Examples of Organophosphate Pesticides

• Diazinon, malathion, methyl parathion, and parathion
• Appear in a wide variety of products: sprays, baits, indoor foggers and bombs, flea collars, pet shampoos, powders, animal dips, and granules
• Malathion has been approved for direct application to food crops such as fruits (e.g., apples and grapes), row crops, and vegetables (e.g., tomatoes).
Carbamates

- Close relatives of the organophosphate pesticides
- Dissipate quickly from the environment as a result of breaking down into other substances
- Some are approved for controlling garden pests (e.g., wasps, hornets, and snails).
- An ingredient in some products applied to furry pets to control ticks and fleas
Examples of Carbamates

- Carbyl (Sevin)
- Aldicarb
- Fenoxy carb
- Propoxur
- Metam sodium
Methyl Isocyanate (MIC)

- An intermediate chemical used for the manufacture of carbamate pesticides.
- When acute exposure occurs, MIC is extremely toxic to life forms (e.g., human beings, aquatic organisms, and plants).
MIC Release in Bhopal, India

• A notorious incident was the accidental release of MIC during a 1984 industrial accident in Bhopal, India, that killed more than 3,800 people.
Figure 7-2 Metam sodium spill into the upper Sacramento River.

Organochlorines

- Derived from chlorinated hydrocarbons, which are chemical compounds that contain chlorine, carbon, and hydrogen
- Characteristically stable and fat-soluble; persist in the environment and bioaccumulate in the food chain
- Associated with suppression of the immune system and cancer
Examples of Organochlorine Pesticides

- DDT
- Lindane
- Chlordane
- Mirex
- Hexachlorobenzene
- Methoxychlor
DDT
(Dichlorodiphenyltrichloroethane)

- Widespread use of DDT began during the early 1940s and reached a maximum during the 1960s.
- Due to concerns about the possible adverse effects upon the health of humans and wildlife, application of DDT was prohibited in 1972 in the U.S.
- Most developed nations banned the use of DDT; however, some countries still continue to use DDT.
Facts about DDT

• Not regarded as a highly toxic pesticide
• Formerly employed worldwide to control insects and harmful mosquitoes that carry malaria
• Was credited at one time with saving millions of people from death due to malaria
Facts about DDT (continued)

- Concentrates in the adipose (fatty) tissues of the body
- Estimated half-life of approximately 10 years
- All living organisms on earth contain some levels of this pesticide.
Human Health Effects of DDT

• Linked to:
  – Cancer (pancreatic, non-Hodgkin’s lymphoma, and breast)
  – Reproductive effects
  – Impaired lactation
  – Falling sperm counts
  – Impaired neurologic function (irritability, dizziness, and numbness)
Pyrethrins

• Derived from natural sources--certain varieties of chrysanthemum flowers
• Have great ability to paralyze and kill flying insects
• Interfere with transmission of neural impulses via action on sodium channels
Use of Pyrethrin Insecticides

• Generally have low concentrations of the active ingredient

• Used inside the home in aerosol cans, insecticide bombs, insecticidal pet shampoos, treatments for lice applied directly to humans, and mosquito repellents

• May be inhaled as a result of spraying and may be ingested in foods
Herbicides/Defoliants

• Examples of chemicals in the category of herbicides and defoliants are:
  – Atrazine
  – Paraquat
  – Agent Orange (2,4-D and 2,4,5-T)
Agent Orange

• Used during the Vietnam War, during Operation Ranch Hand (1962 to 1971)
• Approximately 19 million gallons of defoliants sprayed on 3.6 million acres in Vietnam and Laos
• Contained small amount of dioxins
Health Effects of Agent Orange

• The Institute of Medicine (U.S.) concluded that there was sufficient evidence that Agent Orange was associated with several forms of cancer:
  – Soft tissue sarcoma
  – Non-Hodgkin’s lymphoma
  – Hodgkin’s disease
  – Chronic lymphocytic leukemia
Pesticide Exposure: Who Is at Risk?

- Agricultural workers
- Pets
- Children
- Livestock
- Sensitive subpopulations (e.g., pregnant women)
Dioxins

• “a family of chemical compounds that are unintentional byproducts of certain industrial, non-industrial and natural processes, usually involving combustion.”
Biopesticides

- Pesticides derived from natural materials such as animals, plants, bacteria, and certain minerals

- Examples:
  - Microbial pesticides
  - Plant-Incorporated Protectants
  - Biochemical pesticides
Facts about Dioxins

- A total of 419 compounds in the dioxin family are known to exist.
- Scientists regard only about 30 of these as being the most poisonous.
- Stable, persistent, and bioaccumulate within the food chain.
What Natural Events Produce Dioxins?

- Forest fires and volcanic eruptions emit dioxins into the environment.
- Dioxins that originate from these sources are called “natural background” dioxins.
What Human Activities Produce Dioxins?

- Incineration of industrial and municipal wastes
- Burning of some fuels
- Bleaching of wood pulp for paper manufacturing process
- Manufacture and application of some herbicides
- Tobacco combustion, which gives rise to minute amounts of dioxin in cigarette smoke
Health Effects of Exposure to Dioxin Depend on:

• Duration of exposure
• Frequency of exposure
• When the exposure occurred
• Concentration of the agent
• Route of entry into the body
Health Effects of Exposure to Dioxin Include:

- Chloracne
- Skin rashes
- Skin discoloration
- Growth of excessive body hair
- Liver damage
- Possible cancer risks
- Endocrine effects
- Reproductive and developmental effects
Polychlorinated Biphenyls (PCBs)

- Two common uses before their manufacture was terminated:
  - Insulating fluid in transformers and capacitors
  - Lubricant
- PCBs present in the environment tend to bioaccumulate in fish and other animals used for food and, in turn, impact human health.
PCB Contamination

• PCBs are known to be present at as many as 500 sites denoted on the 1,598 sites that the EPA has provided on the National Priorities List.

• Because of concerns about their environmental and health effects, the manufacture of PCBs was terminated in 1977.
Health Effects of PCBs

• Cause cancer in animals and are designated as probable human carcinogens
• May impact the immune system, reproductive system, and children’s intellectual development
• May limit the development of immune responses to the Epstein-Barr virus and other viral and bacterial infections
Organic Solvents

• Refers to “a liquid substance capable of dissolving other substances; ‘the solvent does not change in forming a solution.’”
Solvents: Modes of Exposure

- Breathing their vapors directly
- Ingesting them in foods and water
- Using foods and cosmetics packed in certain types of plastics
- Smoking cigarettes
- Working in a factory: chronic exposure
- Inhaling vapors released by industrial facilities
- Drinking solvent-contaminated groundwater
Examples of Solvents

- Tetrachloroethylene
- Trichloroethane
- Trichloroethylene (TCE)
- Toluene
- Acetone
- Benzene
Chemicals Used in Plastics
Manufacture: Styrene

- Used for the manufacture of polystyrene resins, which are components of many types of plastics
- Short-term inhalation of styrene can produce central nervous system effects such as muscle weakness, and problems concentrating on tasks; irritation of the respiratory tract also can result.
- Possibly carcinogenic
Chemicals Used in Plastics
Manufacture: Vinyl Chloride

• Used mainly for the manufacture of polyvinyl chloride, which is an ingredient in plastic products such as pipes, vinyl siding for houses, plastic coatings, and upholstery
• Classified as a human carcinogen
Environmental Estrogens

- Some organic chemicals (e.g., chlorinated hydrocarbon pesticides) may have estrogenic activity.
- Sometimes DDT (and its metabolites) is called an endocrine disruptor, meaning that it acts as an antagonist to androgen.
Effects of Environmental Estrogens

- May have abnormal influences on the reproductive systems of exposed humans and animals
- May act as cancer promoters by having an influence on the onset of female cancers that are thought to be caused by estrogenic activity