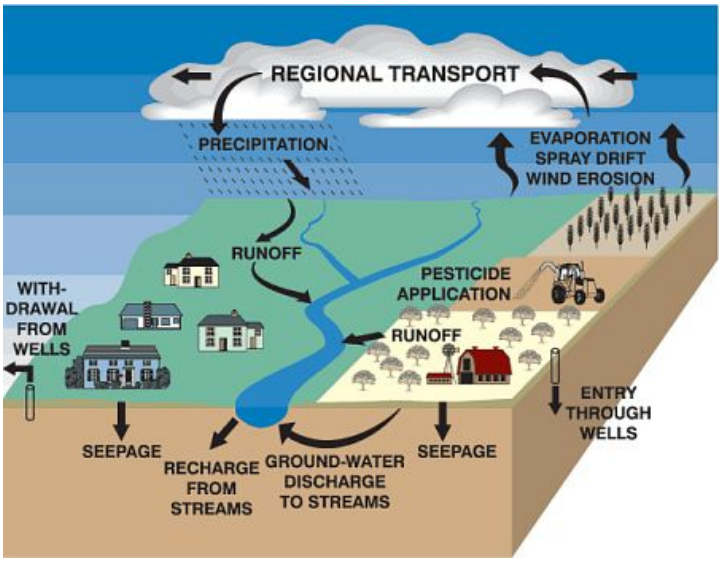
Toxicology of Pesticides

Overview

Pesticides are in widespread use throughout the U.S. and the rest of the world. There are many classes of pesticides including insecticides (pyrethrins and pyrethroids, n-methyl carbamates, organophosphate insecticides, organochlorines, biologicals and acaricides), herbicides (chlorophenoxy agents, pentachlorophenol and dinitrophenolic substances, paraquat, diquat and others), fungicides, incidental pesticides (insect repellents, arsenical pesticides, fumigants, rodenticides, synergists, disinfectants and adjuvants) and many others.[1]



Pathways of pesticide movement in the hydrologic cycle (USGS)[a]

While the chemical nature of pesticides has changed dramatically in the past 50 years, the toxicological considerations associated with pesticide exposure have become much more complex. Even the basic toxicological routes of exposure have been enhanced. For example, some foods have been genetically modified to possess pesticide-like properties. Although generally regarded as "safe" for consumption by consumers, the long-term toxicological impacts of these products are unknown at this time and remain a point of controversy among healthcare professionals (GMO's are currently banned in some countries for this reason). The toxicologist must address all such complexities to properly assess and characterize pesticide exposures.

The widespread use of pesticides and their ubiquitous distribution in the environment raises toxicological concerns with respect to potential adverse effects on human health and the environment. Water is one of the primary routes by which pesticides are transported from an application area to other locations. The U.S. Geological Survey illustration (above) illustrates some of the potential pathways for transport of pesticides through hydrologic systems, which supply water for both humans and natural ecosystems.[2]

Pesticide poisoning can be difficult to evaluate due to short half-lives, metabolic factors, circumstances of exposure and a lack of human epidemiological studies. Each pesticide has specific toxicological properties which must be assessed according to the available scientific evidence and the peer-reviewed toxicological literature. The expert toxicologist must apply these resources objectively to demonstrate or refute causation to reasonable toxicological certainty. Thus, a toxicological assessment based on multiple lines of evidence can make a significant difference in providing scientifically credible toxicological opinions.

It is not possible to provide a comprehensive overview of pesticide toxicology in this brief section; however, the following paragraphs provide a general outline of the basic classes of pesticides with which *TCAS* has gained extensive toxicological experience, performed numerous toxicological exposure assessments, produced written reports and provided expert testimony over a period of more than 28 years.

Click on any substance to view the corresponding entry.

Fungicides | Herbicides | Insecticides | Poison Baits

Click to view other types of hazardous substances.

Environmental Hazards | Industrial Chemicals | Hydrocarbons | Compounds & Metals | Dioxins | Hazardous Substances Index

Fungicides

Show all results for "Fungicides"

Applying fungicide[w]

As the name implies, fungicides are designed to prevent and eliminate fungus infestations. Fungicides are used extensively in industry, agriculture and by consumers. Fungicides protect seed grain during storage, shipment and germination, prevent contamination of mature crops, berries, seedlings, flowers and grasses, suppress mildews, control slime in paper pulps, protect carpet and fabrics and have many other uses. Fungicides vary widely with respect to adverse health effects in humans. There are many types of fungicides including benzenes, strobilurins, thiocarbamates, ethylene bis, dithiocarbamates, thiophthalimides, triazoles, copper compounds, organomercury compounds, organotin compounds, cadmium compounds and organic fungicides. Each type of fungicide causes different acute and chronic symptoms, based on frequency, duration and magnitude of exposure. Most short-term exposures result in irritant injuries to skin and mucous membranes and respiratory irritation. Long-term exposure symptoms can include headache, nausea, vomiting, dizziness, convulsions, loss of consciousness photophobia, mental disturbances and nervous system impacts.[3]

Toxicological considerations with respect to fungicides generally depend on the concentration, dose and duration of exposure to the particular substance contacted, inhaled or ingested. Historically, fungicide poisoning in the U.S. was far more common than at the present time. Some poisonings occurred as a result of consuming seed grain treated with organic mercury or hexachlorobenzene (both of which were subsequently banned as seed grain treatments). Most fungicides currently in use in the U.S. have relatively low toxicity in humans as they tend to be inefficiently absorbed and methods of application are such that exposure circumstances are greatly reduced from historical norms.

Nevertheless, systemic poisonings do still occur in spite of recent U.S. EPA and U.S. FDA regulations designed to protect both manufacturers and the general population. It should be noted, however, that fungicides have many possible uses and they can be ingested via other substances than food. For example, *TCAS* was recently retained to conduct an investigative toxicological risk assessment of a particular fungicide proposed for use in medical marijuana cultivation. Please contact our office for additional information.

Herbicides

Show all results for "Herbicides"

A common herbicide[x]

Herbicides are substances which are toxic to plants and are used to control unwanted vegetation. Although there are a few purely organic herbicidal agents, the vast majority presently in common use in the U.S. have a synthetic or chemical basis. U.S. EPA groups herbicides into four classes of substances: (1) chlorophenoxy herbicides, (2) pentachlorophenol and dinitrophenolic pesticides, (3) paraquat and diquat and (4) other herbicides. Each group has particular toxicological properties and these are addressed independently in EPA guidance.[4]

Chlorophenoxy herbicides contain chlorophenoxy acids, salts and esters. Acute exposure symptoms can include nausea, abdominal pain, headache, generalized weakness and dizziness, elevated body temperature, muscular weakness, peripheral neuropathy and loss of reflexes. Chronic exposure symptoms can include vomiting, diarrhea, confusion and bizarre or aggressive behavior. Ingestion of large amounts can produce severe metabolic acidosis. Most reports of fatal outcomes involve renal failure, acidosis, electrolyte imbalance and multiple organ failure.[5]

Pentachlorophenol (PCP) is a general biocide presently registered in the U.S. as a restricted use pesticide for pressure treatment of utility poles. PCP has been reported to have fetotoxic and embryotoxic properties. Epidemiologic evidence suggests exposed women may be at risk for miscarriages, reduced birth weight and infant malformations. Dinitrophenolic herbicides are nitroaromatic compounds which are highly toxic to humans and animals. Acute symptoms can include profuse sweating, thirst, fever, headache, confusion, malaise and restlessness. Chronic exposure can lead to respiratory distress, cyanosis, tissue anoxia, renal failure, liver damage and death.[6]

Paraquat and diquat are identified chemically as dipyridyls. Acute exposure symptoms include burning pain in the mouth, throat, chest or upper abdomen; pulmonary edema, pancreatitis and renal effects. Chronic symptoms of paraquat can include life-threatening effects on the gastrointestinal tract, kidney, liver, heart and other organs. Pulmonary edema and early lung damage may occur within a few hours of severe acute exposures. Delayed toxic effects can include pulmonary fibrosis and circulatory failure. Diquat can have severe toxic effects on the central nervous system not typical of paraquat poisoning, including brain stem infarction, seizures and coma.[7]

Of the many "other herbicides" classified by U.S. EPA, glyphosate is the most common. Although glyphosate has low acute toxicity in mammals, glyphosate-related poisoning is occasionally reported. Symptoms include gastrointestinal issues, mouth and throat pain, nausea, vomiting, diarrhea and abdominal discomfort. Chronic or intentional oral exposures have resulted in cardiovascular, respiratory and renal system failure. Severe poisoning can result in tachypnea, dysrhythmias, hypotension, non-cardiogenic pulmonary edema, hypovolemic shock, oliguria and respiratory failure.[8]

TCAS has conducted causative investigations associated with herbicides, performed toxicological assessments and/or provided expert testimony subsequent to being retained by defendants, plaintiffs, prosecutors, state attorney generals and/or public defenders' offices. Please contact our office for additional information.

Insecticides

Show all results for "Insecticides"

Insecticides[y]

Insecticides are toxic substances which specifically target insects, insect eggs and larvae. Unlike fungicides and most other pesticides, insecticides are generally intended for broad distribution in crop fields and large growing areas. Additionally, insecticides come in many physical forms and often contain more than one active ingredient, each of which may exhibit different toxic characteristics. As a consequence, different insecticides pose different risk levels to humans, non-target insects, pets and the environment.[9]

Some insecticides are capable of causing profoundly adverse human health impacts and research in this area is continuous and on-going. For example, in 2015 the International Agency for Research on Cancer (IARC) classified dichloro-diphenyl-trichloroethane (DDT) as a probable human carcinogen with scientific evidence linking it to non-Hodgkin lymphoma (NHL), testicular cancer and liver cancer.[10]

U.S. EPA groups insecticides into six substance classes with specific chemical and toxicological properties: (1) pyrethrins and pyrethroids, (2) organophosphates, (3) n-methyl carbamates, (4) organochlorines, (5) biologicals and (6) other insecticides.[11]

- **Pyrethrins and pyrethroids** contain pyrethrum (the oleoresin extract of dried chrysanthemum flowers). Crude pyrethrum is a dermal and respiratory allergen easily absorbed by GI tract and pulmonary membranes. Contact dermatitis and allergic respiratory reactions (rhinitis and asthma) can occur following exposure. Neurotoxicity has been rarely observed in humans.[12]
- **Organophosphates** are efficiently absorbed by inhalation and ingestion and some are highly toxic. Acute exposure symptoms include headache, hypersecretion, spasms, nausea, diarrhea, vomiting, bronchospasm and bradycardia. Chronic exposure symptoms can include seizures and respiratory failure. Reproductive issues have also been linked specifically to organophosphate exposure.[13]
- **N-methyl carbamates** can be absorbed by inhalation, ingestion and dermal routes. Acute exposure symptoms can include muscle weakness, dizziness, sweating, blurred vision, incoordination, slurred speech, headache, salivation, nausea, vomiting, abdominal pain and diarrhea. Chronic exposure symptoms can include coma, seizures, hypotonicity, hypertension and cardio/respiratory depression.[14]
- **Organochlorine** pesticide use has been sharply curtailed in the U.S. as a result of multiple cases of acute neurological toxicity. Acute exposure symptoms can include sensory disturbances, hyperesthesia, paresthesias, headache, tremor, confusion dizziness, nausea and vomiting. Chronic exposure symptoms can include seizures, convulsions, respiratory depression and coma.[15]
- **Biological** pesticides include avermectin, azadirachtin, *bacillus thuringiensis*, eugenol, nicotine, rotenone, sabadilla and others. Exposure symptoms are highly variable based on the specific agents involved. Most can cause GI irritation; higher doses of nicotine and sabadilla may cause adverse central nervous system and cardiovascular effects.[16]
- **Other insecticides** include such substances as benzyl benzoate, borates, chlordimeform, chlorobenzilate, cyhexatin, fluorides, fipronil, haloaromatic compounds, methoprene, neonicotinoids, propargite and others. As with biological insecticides, exposure symptoms are highly variable based on the specific agents involved. Although distinct from the other insecticide classes, each insecticide must be assessed independently as each substance presents a unique set of toxicological characteristics.[17]

TCAS has extensive experience assessing insecticide exposures and has regularly offered toxicological opinions and conducted exposure investigations. A recent insecticide exposure case in our toxicological case studies summarizes the events relating to the death of a man with a history of seizure disorder who was fatally exposed to a particular insecticide in his unventilated basement apartment. (Dr. Sawyer was retained by plaintiff in this instance). Please contact our office for additional information.

Poison Baits

Show all results for "Poison Baits"

Poison Baits[z]

Poison baits are a class of pesticides most commonly used to control rodents and varmints. Although many products have been on the market for decades, new products are regularly emerging and regulations governing their use are becoming more stringent. For example, U.S. EPA recently took action[18] to remove 12 D-Con™ brand mouse and rat poison products from the consumer market as they failed to comply with required safety measures to protect children, pets and wildlife from accidental exposure to rodent baits. The active ingredients (brodifacoum, bromadiolone, difethialone and difenacoum) are very toxic and persistent and have been found widely in non-targeted wildlife.[19] Baits containing chlorophacinone, diphacinone, warfarin, cholecalciferol and bromethalin are less toxic, but any rodent bait has the potential to harm non-targeted wildlife. Recent regulatory changes imposed on poison bait products containing persistent pesticide ingredients (previously marketed to residential consumers) are now available only for commercial use by licensed professionals.

TCAS has significant experience in assessing and solving homicide matters and assessing the toxic health effects of pesticides and poison baits, as well as providing written reports and expert testimony in accordance with federal, state and local regulations. Please contact our office for additional information.

Notes and References

1. U.S. Environmental Protection Agency, "Recognition and Management of Pesticide Poisonings: Sixth Edition," 2013.
2. USGS, "Pesticides in Ground Water - Converse County, Wyoming, 2003-04," February, 2014.
3. U.S. Environmental Protection Agency, "Recognition and Management of Pesticide Poisonings: Fungicides," 2013.
4. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Section III: Herbicides," 2013.
5. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 10, Chlorophenoxys," 2013.
6. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 11, Pentachlorophenol and Dinitrophenolic Pesticides," 2013.
7. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 12, Paraquat and Diquat," 2013.
8. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 13, Other Herbicides," 2013.
9. National Pesticide Information Center, "Insecticides," September, 2015
10. Voice of America, "WHO Agency Says Insecticides Lindane, DDT Linked to Cancer"
11. U.S. Environmental Protection Agency, " Pesticide Poisoning Handbook, Section II, Insecticides," 2013.
12. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 4, Pyrethrins and Pyrethroids," 2013.
13. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 5, Organophosphate Insecticides," 2013.
14. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 6, N-Methyl Carbamate Insecticides," 2013.
15. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 7, Organochlorines," 2013.
16. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 8, Biologicals and Insecticides of Biological Origin," 2013.
17. U.S. Environmental Protection Agency, "Pesticide Poisoning Handbook, Chapter 9, Other Insecticides and Acaricides," 2013.
18. U.S. EPA, "Rodenticide Products for Consumers," March, 2013
19. California Department of Fish and Wildlife, "Rodenticide Baits," Office of Communications, 2013

Images

a. USGS, "Pesticides in Ground Water - Converse County, Wyoming, 2003-04," February, 2014.
b. U.S. Department of Agriculture, AgResearch Magazine, "Applying Fungicide"
c. Texas Commission on Environmental Quality, "Foliar-Applied Herbicides"
d. Voice of America, "WHO Agency Says Insecticides Lindane, DDT Linked to Cancer"
e. Poison bait U.S. Forest Service, Silvicultural Methods in Relation to Selected Wildlife Species

A Message from Dr. William R. Sawyer
Chief Toxicologist, *TCAS, LLC*

"To produce a scientifically credible assessment, the expert toxicologist must determined whether a pesticide exposure was sufficient to produce a particular health effect based on the objective evidence and the prevailing peer-reviewed toxicological literature."

Toxicology Consultants & Assessment Specialists, LLC
(800) 308-0080 or send a message
6450 Pine Avenue, Sanibel, FL 33957 **(239) 472-2436**
29 Fennell Street, Skaneateles, NY 13152 **(315) 685-2345**
View Dr. Sawyer's profiles on LinkedIn.com, AlmExperts.com and Jurispro.com