Pesticide Safety Fact Sheet

Potential Health Effects of Pesticides

For all pesticides to be effective against the pests they are intended to control, they must be biologically active, or toxic. Because pesticides are toxic, they are also potentially hazardous to humans, animals, other organisms, and the environment. Therefore, people who use pesticides or regularly come in contact with them must understand the relative toxicity, potential health effects, and preventative measures to reduce exposure to the product they use.

Pesticide Toxicity and Exposure

Hazard, or risk, of using pesticides is the potential for injury, or the degree of danger involved in using a pesticide under a given set of conditions. Hazard depends on the toxicity of the pesticide and the amount of exposure to the pesticide and is often illustrated with the following equation:

Hazard = Toxicity x Exposure.

The toxicity of a pesticide is a measure of its capacity or ability to cause injury or illness. The toxicity of a particular pesticide is determined by subjecting test animals to varying dosages of the active ingredient (a.i.) and each of its formulated products. The active ingredient is the chemical component in the pesticide product that controls the pest. By understanding the difference in toxicity levels of pesticides, a user can minimize the potential hazard by selecting the pesticide with the lowest toxicity that will control the pest.

Applicators may have little or no control over the availability of low-toxicity products or the toxicity of specific formulated products. However, applicators can minimize or nearly eliminate exposure—and thus reduce hazard—by following the label instructions, using personal protective clothing and equipment (PPE), and handling the pesticide properly. For example, more than 95 percent of all pesticide exposures come from dermal exposure, primarily to the hands and forearms. By wearing a pair of unlined, chemical-resistant gloves, this type of exposure can be nearly eliminated.

Acute Toxicity and Acute Effects

Acute toxicity of a pesticide refers to the chemical's ability to cause injury to a person or animal from a single exposure, generally of short duration. The harmful effects that occur from a single exposure by any route of entry are termed "acute effects." The four routes of exposure are dermal (skin), inhalation (lungs), oral (mouth), and the eyes. Acute toxicity is determined by examining the dermal toxicity,

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inhalation toxicity, and oral toxicity of test animals. In addition, eye and skin irritation are also examined.

Acute toxicity is measured as the amount or concentration of a toxicant—the a.i.—required to kill 50 percent of the animals in a test population. This measure is usually expressed as the LD_{50} (lethal dose 50) or the LC_{50} (lethal concentration 50). Additionally, the LD_{50} and LC_{50} values are based on a single dosage and are recorded in milligrams of pesticide per kilogram of body weight (mg/kg) of the test animal or in parts per million (ppm). LD_{50} and LC_{50} values are useful in comparing the toxicities of different active ingredients and different formulations containing the same active ingredient. *The lower the LD_{50} or LC_{50} value of a pesticide product, the greater its toxicity to humans and animals.* Pesticides with a high LD_{50} are the least toxic to humans if used according to the directions on the product label.

Chronic Toxicity and Chronic Effects

The chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to the active ingredient. Any harmful effects that occur from small doses repeated over a period of time are termed "chronic effects." Suspected chronic effects from exposure to certain pesticides include birth defects, toxicity to a fetus, production of benign or malignant tumors, genetic changes, blood disorders, nerve disorders, endocrine disruption, and reproduction effects. The chronic toxicity of a pesticide is more difficult than acute toxicity to determine through laboratory analysis.

Signal Words

Products are categorized on the basis of their relative acute toxicity (their LD_{50} or LC_{50} values). Pesticides that are classified as highly toxic (Toxicity Category I) on the basis of either oral, dermal, or inhalation toxicity must have the signal words DANGER and POISON printed in red with a skull and crossbones symbol prominently displayed on the front panel of the package label. The Spanish equivalent for DANGER, "PELIGRO," must also appear on the labels of highly toxic chemicals. The acute (single dosage) oral LD_{50} for pesticide products in this group ranges from a trace amount to 50 mg/kg. For example, exposure of a few drops of a material taken orally could be fatal to a 150-pound person.

Some pesticide products have just the signal word DANGER, which tells you nothing about the acute toxicity, just that the product can cause severe eye damage or severe skin irritation.

Pesticide products considered moderately toxic (Toxicity Category II) must have the signal word WARNING and "AVISO" (the Spanish equivalent) displayed on the product label. In this category, the acute oral LD_{50} ranges from 50 to 500 mg/kg. A teaspoon to an ounce of this material could be fatal to a 150-pound person.

Pesticide products classified as either slightly toxic or relatively nontoxic (Toxicity Categories III and IV) are required to have the signal word CAUTION on the pesticide label. Acute oral LD_{50} values in this group are greater than 500 mg/kg. An ounce or more of this material could be fatal to a 150-pound person.

Table 1 summarizes the LD_{50} and LC_{50} values for each route of exposure for the four toxicity categories and their associated signal word. For example, an active ingredient with a dermal LD_{50} of 1,000 mg/kg would be in Toxicity Category II with a WARN-

Table 1. Toxicity categories for active ingredients.

Routes of Exposure	Toxicity Category I	II	III	IV
Oral LD_{50}	Up to and including 50 mg/kg	50–500 mg/kg	500–5,000 mg/kg	>5,000 mg/kg
Inhalation LC_{50}	Up to and including 0.2 mg/l	0.2–2 mg/l	2–20 mg/l	>20 mg/l
Dermal LD_{50}	Up to and including 200 mg/kg	200–2,000 mg/kg	2,000–20,000 mg/kg	>20,000 mg/kg
Eye Effects	Corrosive corneal opacity not reversible within 7 days	Corneal opacity reversible within 7 days; irritation persisting for 7 days	No corneal opacity; irritation reversible within 7 days	No irritation
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours
Signal Word	DANGER POISON	WARNING	CAUTION	CAUTION

Adapted from 40 CFR Part 156.

ING signal word. Keep in mind that an active ingredient may have a high LD_{50} placing it in a Toxicity Category II, III, or IV but also have corrosive eye/skin effects that take priority and place it in Toxicity Category I.

All pesticide toxicity values, including the LD_{50}, can be found on the product's Material Safety Data Sheet (MSDS). Pesticide labels and MSDS can be obtained from retailers or manufactures. In addition, most products also have information that can be found on the Internet. The following Web page lists some of the more common search engines used to find pesticide labels and MSDS: http://www.pested.psu.edu/resources/web/labels.shtml.

Symptoms of Pesticide Poisoning

The symptoms of pesticide poisoning can range from a mild skin irritation to coma or even death. Different classes or families of chemicals cause different types of symptoms. Individuals also vary in their sensitivity to different levels of these chemicals. Some people may show no reaction to an exposure that may cause severe illness in others. Because of potential health concerns, pesticide users and handlers must recognize the common signs and symptoms of pesticide poisoning.

The effects, or symptoms, of pesticide poisoning can be broadly defined as either topical or systemic. Topical effects generally develop at the site of pesticide contact and are a result of either the pesticide's irritant properties (either the active and/or inert ingredient) or an allergic response by the victim. Dermatitis, or inflammation of the skin, is accepted as the most commonly reported topical effect associated with pesticide exposure. Symptoms of dermatitis range from reddening of the skin to rashes and/or blisters.

Some individuals tend to cough, wheeze, or sneeze when exposed to pesticide sprays. Some individuals react to the strong odor and irritating effects of petroleum distillates used as carriers in pesticide products. One symptom is that the eyes, mucous membranes of the nose, and even the sensitive linings of the mouth and back of the throat feel raw and scratchy. This symptom usually subsides within a few minutes after a person is removed from the exposure to the irritant. However, a reaction to a pesticide product that causes someone not only to sneeze and cough but also to develop severe acute respiratory symptoms is more likely to be a true hypersensitivity or allergic reaction. Symptoms of a true allergic reaction range from reddening and itching of the eyes and skin to respiratory discomfort often resembling an asthmatic condition.

Systemic effects are quite different from topical effects. They often occur away from the original point of contact as a result of the pesticide being absorbed into and distributed throughout the body. Systemic effects often include nausea, vomiting, fatigue, headache, and intestinal disorders. In advanced poisoning cases, the individual may experience changes in heart rate, difficulty breathing, convulsions, and coma, which could lead to death.

Seeking Medical Attention

Be alert for the early signs and symptoms of pesticide poisoning in yourself and others. These often occur immediately after exposure, but they could be delayed for up to 24 hours. If you are having symptoms but are unsure if they are pesticide related, at least notify someone in case your symptoms become worse. But when symptoms appear after contact with pesticides, you should seek medical attention immediately. At this time, call the **National Poison Center at 1-800-222-1222** for guidance on the proper response to your symptoms. This number will direct your call to the nearest poison center, which is staffed on a 24-hour basis.

If safe to do so, take the pesticide container to the telephone. (However, if the pesticide container is contaminated, write down the product name, percentage of active ingredients, and take to the phone.) The product label provides medical personnel information such as active ingredients, an antidote, and an emergency contact number for the manufacturer of the product. If the Material Safety Data Sheet is available, also take this with you because it frequently contains additional information for medical personnel. If you must go to the hospital or doctor's office, take the entire container, including the label, with you. In order to avoid inhaling fumes or spilling the contents, make sure the container is tightly sealed and never put it in the enclosed passenger section of a vehicle.

Harmful Effects of Some Pesticide Families

Fungicides

The acute toxicity of fungicides to humans is generally considered to be low, but fungicides can be irritating to the skin and eyes. Inhalation of spray mist or dust from these pesticides may cause throat irritation, sneezing, and coughing. Chronic exposures to lower concentrations of fungicides can cause adverse health effects. Most cases of human fungicide poisonings have been from consumption of seed grain. To prevent these types of poisonings, fungicide treatment now includes a brightly colored dye to clearly indicate that the seed has been treated. Table 2 summarizes the signs and symptoms of acute exposures to commonly used fungicides.

Herbicides

In general, herbicides have a low acute toxicity to humans because the physiology of plants is so different than that of humans. However, there are exceptions; many can be dermal irritants since they are often strong acids, amines, esters, and phenols. Inhalation of spray mist may cause coughing and a burning sensation in the nasal passages and chest. Prolonged inhalation sometimes causes dizziness. Ingestion will usually cause vomiting, a burning sensation in the stomach, diarrhea, and muscle twitching. Table 3 summarizes the signs and symptoms of acute exposures to commonly used herbicides.

Insecticides

Insecticides cause the greatest number of pesticide poisonings in the United States. The most serious pesticide poisonings usually result from acute exposure to organophosphate and carbamate insecticides. Organophosphate insecticides include chlorpyrifos, diazinon, dimethoate, disulfoton, malathion, methyl parathion, and ethyl parathion. The carbamate compounds include carbaryl, carbofuran, methomyl, and oxamyl. Organophosphates and carbamates inhibit the enzyme cholinesterase, causing a disruption of the nervous system. All life forms with cholinesterase in their nervous system, such as insects, fish, birds, humans, and other mammals, can be poisoned by these chemicals.

Table 4 summarizes the signs and symptoms from acute exposures to commonly used insecticides.

Table 2. Signs and symptoms of acute exposure for several fungicide active ingredients.

Active Ingredient	Brand Name	Signs and Symptoms
Azoxystrobin	Abound, Quadris	Irritating to skin, eyes, respiratory tract
Captan	Captol, Orthocide	Irritating to skin, eyes, respiratory tract
Chlorothalonil	Bravo, Daconil	Irritation to skin, mucous membranes of the eye, respiratory tract Allergic contact dermatitis
Copper Compounds	Bordeaux mixture, Copper sulfate	Irritating to skin, eyes, respiratory tract Salts are corrosive to mucous membranes and cornea Metallic taste, nausea, vomiting, intestinal pain
Mancozeb	Dithane M-45, Manzate 200	Irritating to skin, eyes, respiratory tract
Maneb	Dithane M-22, Manzate	Irritating to skin, eyes, respiratory tract Skin disease in occupationally exposed individuals
Pentachloronitrobenzene	PCNB, Terraclor	Allergic reactions
Sulfur	Cosan, Thiolux	Irritating to skin, eyes, respiratory tract Breath odor of rotten eggs Diarrhea Irritant dermatitis in occupationally exposed individuals
Thiram	Polyram-Ultra, Spotrete-F	Irritating to skin, eyes, respiratory mucous membranes
Ziram	Cuman, Vancide	Irritating to skin, eyes, respiratory tract Prolonged inhalation causes neural and visual disturbances

Table 3. Signs and symptoms of acute exposure for several herbicide active ingredients.

Active Ingredient	Brand Name	Signs and Symptoms
2,4-dichlorophenoxyacetic acid	2,4-D, Barrage	Irritating to skin, mucous membranes Vomiting, headache, diarrhea, confusion Bizarre or aggressive behavior Muscle weakness in occupationally exposed individuals
Acetochlor	Harness, Surpass	Irritating to skin, eyes, respiratory tract
Atrazine	Aatrex, Atranex	Irritating to skin, eyes, respiratory tract Abdominal pain, diarrhea, vomiting Eye irritation, irritation of mucous membranes, skin reactions
Dicamba	Banvel, Metambane	Irritating to skin, respiratory tract Loss of appetite (anorexia), vomiting, muscle weakness, slowed heart rate, shortness of breath Central nervous system effects
Glyphosate	Rodeo, Roundup	Irritating to skin, eyes, respiratory tract
Mecoprop	Kilporp, MCPP	Irritating to skin, mucous membranes Vomiting, headache, diarrhea, confusion Bizarre or aggressive behavior Muscle weakness in occupationally exposed individuals
Metolachlor	Bicep, Dual	Irritating to skin, eyes
Paraquat	Gramoxone	Burning in mouth, throat, chest, upper abdomen Diarrhea Giddiness, headache, fever, lethargy Dry, cracked hands, ulceration of skin
Pendimethalin	Prowl, Stomp	Irritating to skin, eyes, respiratory tract
Propanil	Propanex, Stampede	Irritating to skin, eyes, respiratory tract

To understand how the organophosphate and carbamate insecticides affect the nervous system, one needs to understand how the nervous system actually works. The nervous system, which includes the brain, is the most complex system in the body consisting of millions of cells that make up a communications system within the organism. Messages or electrical impulses (stimuli) travel along this complex network of cells. Nerve cells or neurons do not physically touch each other; rather there is a gap or synapse between cells. The impulses must cross or "bridge" the synapse between nerve cells in order to keep the message moving along the entire network.

When an impulse reaches the synapse, the chemical acetylcholine is released to carry the message on to the next cell. Acetylcholine is the primary chemical responsible for the transmission of nerve impulses across the synapse of two neurons. After the impulse is transmitted across the synapse, the acetylcholine is broken down by the enzyme cholinesterase. Once this occurs, the synapse is "cleared" and ready to receive a new transmission.

Organophosphate and carbamate insecticides inhibit the activity of cholinesterase, resulting in a buildup of acetylcholine in the body. An increase in acetylcholine results in the uncontrolled flow of nerve transmissions between nerve cells. The nervous system becomes "poisoned"; the accumulation of acetylcholine causes the continual transmission of impulses across the synapses.

The effects of organophosphate or carbamate poisoning can result in both systemic and topical symptoms. Direct exposure of the eye, for example, can cause topical symptoms such as constriction of the pupils, blurry vision, an eyebrow headache, and severe irritation and reddening of the eyes. Symptoms and signs of systemic poisonings are almost entirely due to the accumulation of acetylcholine at the nerve endings.

The onset of symptoms depends on the route of entry and the severity of the poisoning. Gastric symptoms such as stomach cramps, nausea, vomiting, and diarrhea appear early if the material has been ingested. Similarly, salivation, headache, dizziness, and

excessive secretions that cause breathing difficulties are initial symptoms if the material has been inhaled. Involvement of the respiratory muscles can result in respiratory failure. Stomach, intestinal, and respiratory symptoms usually appear at the same time if the pesticide is absorbed through the skin. In children, the first symptom of poisoning may be a convulsion.

In advanced poisonings, the victim is pale, sweating, and frothing at the mouth. The pupils are constricted and unresponsive to light. Other symptoms include changes in heart rate, muscle weakness, mental confusion, convulsions, and/or coma. The victim may die if not treated.

Cholinesterase Testing

Those who regularly work with organophosphates and carbamates should consider having periodic cholinesterase tests. The blood cholinesterase test measures the effect of exposure to organophosphate and carbamate insecticides. Since cholinesterase levels can vary considerably among individuals, a "baseline" must be established for each person. In fact, a small percentage of the population has a genetically determined low level of cholinesterase. Even minimal exposure to cholinesterase inhibitors can present a substantial risk to these people. Baseline testing should always be done during the time of year when pesticides are not being used, or at least 30 days from the most recent exposure. Establishing a baseline value often requires two tests performed at least 72 hours apart but within 14 days of each other. If the test results differ by as much as 20 percent, a third test is often recommended.

Cholinesterase tests can be repeated during times when organophosphate and carbamate insecticides are being used and then compared with the baseline level. The purpose of routine cholinesterase monitoring is to enable a physician to recognize the occurrence of excessive exposure to organophosphates and carbamates. If a laboratory test shows a cholinesterase drop of 30 percent below the estab-

Table 4. Signs and symptoms of acute exposure for several insecticide active ingredients.

Active Ingredient	Brand Name	Signs and Symptoms
Acephate (organophosphate)	Orthene	Headache, excessive salivation and tearing, muscle twitching, nausea, diarrhea Respiratory depression, seizures, loss of consciousness Pinpoint pupils
Aldicarb (N-methyl carbamate)	Temik	Malaise, muscle weakness, dizziness, sweating Headache, salivation, nausea, vomiting, abdominal pain, diarrhea Nervous system depression, pulmonary edema in serious cases
Carbaryl (N-methyl carbamate)	Sevin	Malaise, muscle weakness, dizziness, sweating Headache, salivation, nausea, vomiting, abdominal pain, diarrhea Nervous system depression, pulmonary edema in serious cases
Chlorpyrifos (organophosphate)	Dursban	Headache, excessive salivation and tearing, muscle twitching, nausea, diarrhea Respiratory depression, seizures, loss of consciousness Pinpoint pupils
Endosulfan (organochlorine)	Thiodan	Itching, burning, tingling of skin Headache, dizziness, nausea, vomiting, lack of coordination, tremor, mental confusion Seizures, respiratory depression, coma
Malathion (organophosphate)	Cythion	Headache, excessive salivation and tearing, muscle twitching, nausea, diarrhea Respiratory depression, seizures, loss of consciousness Pinpoint pupils
Methyl Parathion (organophosphate)	Penncap-M	Headache, excessive salivation and tearing, muscle twitching, nausea, diarrhea Respiratory depression, seizures, loss of consciousness Pinpoint pupils
Phosmet (organophosphate)	Imidan	Headache, excessive salivation and tearing, muscle twitching, nausea, diarrhea Respiratory depression, seizures, loss of consciousness Pinpoint pupils
Pyrethrins (natural origin)		Irritating to skin and upper respiratory tract Contact dermatitis and allergic reactions—asthma
Pyrethroids (synthetic pyrethrin)	Cypermethrin, permethrin	Abnormal facial sensation, dizziness, salivation, headache, fatigue, vomiting, diarrhea Irritability to sounds or touch Seizures, numbness

lished baseline, the worker should be retested immediately. If a second test confirms the drop in cholinesterase, the pesticide handler or agricultural worker should be removed from further contact with organophosphate and carbamate insecticides until cholinesterase levels return to the pre-exposure baseline range. Your primary care physician can help to establish the frequency of this testing program.

Exposure and Preventative Measures

As mentioned earlier, the hazard or risk involved with using a pesticide depends on both the toxicity of the product and the amount of exposure to the product (Hazard = Toxicity x Exposure). Ideally, use a low-toxicity product when possible, but even they can be harmful if your exposure level is high. However, regardless of the product's toxicity, if the exposure level is low, then the hazard will also be low. To reduce the possibility of exposure and to protect your health, always wear the personal protective equipment (PPE) as indicated on the product label. The following are general PPE guidelines to protect against the four routes of entry.

Dermal

More than 95 percent of all exposures are dermal. Dermal absorption may occur as the result of a splash, spill, or drift or when cleaning or repairing equipment. Wear unlined, chemical-resistant gloves to eliminate most dermal exposures. Minimum dermal protection for most pesticides consists of a long-sleeved shirt, long trousers, gloves, and proper footwear. For extra precaution, consider wearing coveralls, a waterproof hat, and unlined rubber boots. Additionally, wearing a liquid-proof apron or rain suit is recommended when mixing and pouring concentrates or when using highly toxic products.

Inhalation

For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system. Respiratory protection is especially important when pesticide powders, dusts, gases, vapors, or small spray droplets can be inhaled. Use the respirator as designed for its intended use, and always follow the manufacturer's instructions. Select only equipment approved by the National Institute of Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA).

Oral

Accidental oral exposure most frequently occurs when pesticides have been taken from the original container and put into an unlabeled bottle or food container. Unfortunately, children are the most common victims in these situations. Store pesticides only in their original containers. Keep the original label attached to the container. Never use your mouth to clear a spray line or to siphon a pesticide from a tank or container. After handling or working with pesticides, wash your hands and face thoroughly with soap and water before eating, drinking, or smoking.

Eyes

Eyes are very sensitive to many pesticides and, considering their size, are able to absorb large amounts of chemical. Serious eye exposure can result from a splash, spill, or drift or by rubbing the eyes with contaminated hands or clothing. Tight-fitting chemical splash goggles or a full-face shield should be worn if there is any chance of getting pesticides in the eyes, especially when pouring or mixing concentrates and handling dusts. When pouring from a container, keep the container below eye level to avoid splashing or spilling chemicals on your face or protective clothing.

Summary

All pesticides have the potential to be harmful to humans, animals, other living organisms, and the environment if used incorrectly. The key to reducing health hazards when using pesticides is to always limit your exposure by wearing PPE and use a low-toxicity pesticide when available. Reading the label and practicing safe work habits will minimize hazards from the use of pesticides.

References

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National Poison Center
1-800-222-1222

Calling the toll-free National Poison Center hotline above will connect you to the nearest poison center. Pennsylvania residents are served by the Pittsburgh Poison Center and the Poison Control Center in Philadelphia.

Pesticide Safety Fact Sheets are produced by the Pesticide Education Program in Penn State's College of Agricultural Sciences. Topics covered in the series include

- pesticide laws and regulations,
- handling chemical spills,
- personal protective gear,
- pesticides in the environment,
- equipment care and cleaning,
- pesticide toxicity and health effects.

For a complete list of fact sheets and electronic copies or for more information about the Pesticide Education Program, visit http://www.pested.psu.edu/ on the Web.

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Penn State College of Agricultural Sciences research, extension, and resident education programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

This publication is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. For information telephone 814-865-6713.

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Produced by Information and Communication Technologies in the College of Agricultural Sciences

CODE# **UO198** Rev5M2/07mpc1795