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Managing the Risk of Pesticide Poisoning and Understanding the Signs and Symptoms

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The potential for accidents with pesticides is real. Accidental exposure or overexposure to pesticides can have serious consequences. While most pesticides can be used with relatively little risk when label directions are followed, some are extremely toxic and require special precautions.

In 2010, the Poison Control Centers received 91,940 calls (3.3 percent of all human exposures) related to pesticide exposures. That year, pesticides were responsible for about 3 percent of all accidental exposures to children 5 years and younger and almost 6 percent for adults. In addition, pesticides were the cause of about 4 percent of children's deaths reported to the Poison Control Centers.

Routes of Exposure

Pesticides can enter the human body three ways: 1) ***dermal exposure***, by absorption through the skin or eyes; 2) ***oral exposure***, through the mouth; and 3) through ***inhalation or respiratory exposure***, by breathing into the lungs.

Dermal exposure results in absorption immediately after a pesticide contacts the skin or eyes. Absorption will continue as long as the pesticide remains in contact with the skin or eyes. The rate at which dermal absorption occurs is different for each part of the body (*Figure 1*). The relative absorption rates are determined by comparing each respective absorption rate with the forearm absorption rate, given a rate of 1.

It is easy to transfer pesticide residues from one part of the body to another. For example, residues can be inadvertently moved from the palm of a hand that has an absorption rate of 1.3, to a sweaty forehead (4.2) or to the genital area (11.8). When this occurs, the applicator increases the potential for pesticide poisoning.

Oral exposure may result in serious illness, severe injury, or even death. Pesticides can be ingested by accident, through carelessness, or intentionally. The most common accidental oral exposure occurs when a pesticide is taken from its original container and put into an unlabeled bottle, jar, or food container. A pesticide stored in a food container can be especially inviting to a child. When pesticides are managed and stored properly, children should not be able to touch them.

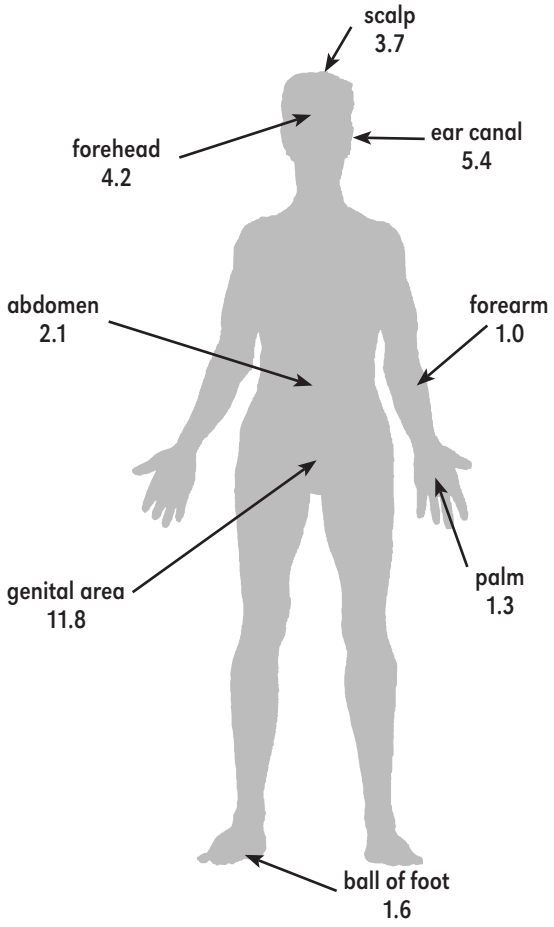

Figure 1. Absorption rates of the different parts of the body based on the absorption rate of the forearm.

Inhalation or respiratory exposure is particularly hazardous because the lungs can rapidly absorb pesticides into the bloodstream. Some pesticides can cause serious damage to the nose, throat, and lung tissue if inhaled in sufficient amounts. Vapors and very small particles pose the most serious risks.

Lungs can be exposed to pesticides by inhalation of powders, airborne droplets, or vapors. Concentrated wettable powders can pose a hazard if inhaled during mixing. The hazard from inhaling pesticide spray droplets usually is fairly low when dilute sprays are applied with low-pressure application equipment, because most

droplets are too large to remain airborne long enough to be inhaled. The potential for respiratory exposure increases, however, when high pressure, ultra low volume (ULV), or fogging equipment is used. Droplets produced during these operations are fog-sized (less than 10 microns) or mist-sized (10 to 100 microns) and can be carried on air currents for a considerable distance.

Follow these guidelines to reduce the risk of pesticide exposure:

- Always store pesticides in their original labeled containers.
- Never use your mouth to clear a spray hose or nozzle, or to begin siphoning a pesticide.
- Always leave the work area and wash thoroughly before eating, drinking, using tobacco, or using the toilet.
- Read the pesticide label and wear appropriate clothing and personal protective equipment (PPE). The label has precautionary statements listing hazards to humans, indicating whether risks are due to oral, dermal, and/or respiratory exposure.

Pesticide Toxicity

The toxicity of a pesticide can be measured several ways. Determining the toxicity of a pesticide to humans is not easy, since humans cannot be used as test subjects. Because of this, other animals, such as rats, are used. If a pesticide is poisonous to rats, however, it is not necessarily poisonous to dogs, cows, wildlife, or people. Toxicity studies are only guidelines: they are used to estimate how poisonous one pesticide is compared with another. Some pesticides are dangerous in one large dose or exposure, which is known as acute toxicity. Others can be dangerous after small, repeated doses, called chronic toxicity.

Measuring toxicity. The LD_{50} (lethal dose, 50 percent) describes the dose of a pesticide that will kill half of a group of test animals (rats, mice, or rabbits) from a single exposure or dose by a dermal, oral, or inhalation route. The LD_{50} is the dose per unit of body weight, such as milligrams per kilogram (mg/kg). A pesticide with a lower LD_{50} is more toxic than a pesticide with a higher number because it takes less of the pesticide to kill half of the test animals. For example, a pesticide with an LD_{50} of 10 mg/kg is much more toxic than a pesticide with an LD_{50} of 1,000 mg/kg.

The toxicity of fumigant pesticides is described in terms of the concentration of the pesticide in the air, LC_{50} (lethal concentration, 50 percent). Researchers use a similar system to test the potential effects of pesticides on aquatic organisms in water.

Acute toxicity of a pesticide refers to the effects from a single exposure or repeated exposures over a short time, such as an accident when mixing or applying pesticides. Various signs and symptoms are associated with acute poisonings. A pesticide with a high acute toxicity can be deadly even if a small amount is absorbed. Acute toxicity can be measured in terms of acute oral, dermal, or inhalation toxicity.

Chronic toxicity refers to the effects of long-term or repeated low-level exposures to a toxic substance. The effects of chronic exposure do not appear immediately after first exposure: years may pass before signs and symptoms develop. Possible effects of long-term exposure to some pesticides include:

- cancer, either alone or by assisting other chemicals;
- genetic changes;
- birth defects in offspring following exposure of the pregnant female;
- tumors, not necessarily cancerous;
- liver damage;
- reproductive disorders;
- nerve damage;
- interfering with the endocrine system (hormones and glands that regulate many body functions); and
- sensitivity or allergic reactions such as irritation of the skin and/or respiratory tract.

The effects of chronic toxicity, as with acute toxicity, are dose-related. Low-level exposure to chemicals that have the potential to cause long-term effects may not cause immediate injury, but repeated exposures through careless handling or misuse can greatly increase the risk of chronic adverse effects.

Table I. Signal words and relative toxicities used on labels of pesticide products.

GROUP	SIGNAL WORD	TOXICITY RATING	ORAL LETHAL DOSE for a 150-pound Human[a]
I	Danger[b]	Highly toxic	Few drops to 1 tsp
II	Warning	Moderately toxic	1 tsp to 1 Tbsp
III	Caution	Slightly toxic	1 Tbsp to a pint
IV	Caution (signal word not always required)	Relatively nontoxic	More than a pint

[a]The lethal dose is less than those listed for a child or for a person under 150 lb, and more for a person over 150 lb.
[b]The skull and crossbones symbol and the word "Poison" sometimes are printed with the signal word "Danger."

Signal Words

Nearly all pesticides are toxic at some dose. They differ only in the *degree* of toxicity. All pesticides are potentially dangerous to people who have had excessive exposure. Every label of a pesticide product will have one of three signal words that clearly indicates the degree of toxicity associated with that product (*Table I*). The signal word indicates the degree of risk to a user, not the effectiveness of the product in controlling the target pest.

Read the Pesticide Label

Pesticide labels also include statements about route of entry and specific actions that must be taken to avoid exposure. Route of entry statements indicate the outcome that can be expected from exposure. For example, a pesticide label might read, "*Poisonous if swallowed, inhaled, or absorbed through the skin. Rapidly absorbed through skin and eyes.*" This indicates that the pesticide is a potential hazard through all three routes of entry, and that skin and eye contact are particularly hazardous. Specific action statements normally follow the route of entry statement and indicate what must be done to prevent poisoning accidents. In the case of the pesticide discussed above, the statement might read, "*Do not get in eyes, on skin, or on clothing. Do not breathe spray mist.*"

The route of entry and specific action statements usually are followed by first aid instructions (see *Table II*). Read this section of the label carefully prior to using the pesticide so you know what to do if an accidental exposure occurs. By following the instructions carefully, you will help limit the amount of exposure you or the victim will receive, even after initial contact with the pesticide.

Table II. Example of a first aid section from a pesticide label.

FIRST AID:	Call a poison control center or doctor for treatment advice.
IF IN EYES:	Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
IF INHALED:	Move the victim to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.
IF SWALLOWED:	This product will cause gastrointestinal tract irritation. Immediately dilute by having the victim swallow water or milk. Get medical attention. Never give anything by mouth to an unconscious person.

Another important section on a pesticide label provides instructions for pesticide applicators and other handlers on the use of personal protective equipment (PPE) to help them limit pesticide exposure. It lists specific protective clothing and equipment requirements. For example, the label for a moderately toxic pesticide might read, "*Applicators and other handlers must wear long-sleeved shirts and long pants, shoes plus socks, protective eyewear, and chemical-resistant gloves.*"

Manage Your Risk

Wear PPE required by the label when handling or applying pesticides to reduce the risk of exposure to pesticides. If none are listed, wear appropriate clothing, including a long-sleeved shirt, long pants, shoes, socks, and chemical-resistant gloves. Risk of pesticide poisoning is directly related to the toxicity of a pesticide and the level of exposure, which is reflected in the Risk Formula:

Risk = Toxicity *x* Exposure.

Understanding the toxicity of a product and the potential for personal exposure will help you to lower your risk. No matter how toxic a pesticide is, if the amount of exposure is kept low, risk can be held at an acceptably low level. The toxicity of a pesticide can't be changed, but an applicator can manage and reduce risk by selecting less toxic pesticides, carefully following the label instructions, and wearing the required PPE.

Recognizing Signs and Symptoms of Poisoning

Anyone who may be exposed to pesticides or is working with someone who may be exposed should be aware of the signs and symptoms of pesticide poisoning. *Signs* can be seen by others. Vomiting, sweating, and pinpoint pupils are signs of pesticide poisoning. *Symptoms* are any changes in normal condition that can be described by the victim of poisoning, including nausea, headache, weakness, dizziness, and others. Knowledge of these signs and symptoms will allow for prompt treatment and help prevent serious injury. People who are frequently involved with pesticides should become familiar with the following important steps.

1. Recognize the signs and symptoms of pesticide poisoning for those pesticides commonly used or to which people may be exposed. Often, pesticide poisoning resembles flu symptoms.
2. If you suspect poisoning due to a pesticide, get immediate help from a local hospital, physician, or the nearest Poison Control Center (800-222-1222).

3. Identify the pesticide to which the victim was exposed, giving the chemical name and the EPA registration number found on the label, if possible. Provide this information to medical authorities.
4. Have a copy of the pesticide label available when medical attention begins. The label provides information that will be useful to those assisting a victim of pesticide poisoning.
5. Know emergency measures you can undertake until help arrives or the victim can be taken to the hospital. Both first aid and medical treatment procedures are listed on the product label.

Recognizing Common Pesticide Poisonings

All pesticides in a given chemical group generally affect the human body in the same way. Severity of the effects, however, varies depending on the formulation, concentration, toxicity, and route of exposure of the pesticide. Therefore, it is important to know both the type of pesticide being used and the signs and symptoms associated with poisoning from it.

Pesticides that present the greatest potential health risks and those in which the mode of action is better understood are covered in the following sections. Categories of pesticides with similar signs and symptoms are covered together.

The listings of pesticides in *Tables III, IV, and V* are not necessarily complete, nor do they guarantee that the product is currently registered. They do, however, represent products that are or have been used in Nebraska. The Environmental Protection Agency (EPA) and Nebraska Department of Agriculture (NDA) maintain registrations for pesticide products. The EPA attempts to discontinue use of the most toxic products and replace them with less toxic products. Pesticides mentioned in this publication may not currently be registered for use in Nebraska, but still may be found on the shelves of applicators. Therefore, they still present risk, so signs and symptoms are included. Mention of a trade name does not constitute endorsement of a product, nor does omission constitute criticism.

Insecticides

Insecticides have many different modes of action. Some act on the nervous system of the insect. Others slow the production of energy that an insect needs to survive. Another type slows or stops the production of chitin, a major component of an insect exoskeleton, so the insect can't molt. Insect growth regulators, another type, also may prevent an insect from molting or keep it from maturing and reproducing. Some insecticides disrupt the water balance in an insect, causing rapid water loss and eventual death. The modes of action involving the nervous system and energy production may affect not only insects, but other animals as well. Insecticides such as the insect growth regulators typically are specific to insects. The following is a list of insecticides grouped by their chemical makeup.

Organophosphate and Carbamate Insecticides

Most cases of pesticide poisoning involve either organophosphate or carbamate insecticides. Both chemical groups affect humans by inhibiting acetyl cholinesterase, an enzyme essential for proper function of the nervous system. Without acetyl cholinesterase, nerve impulses continue and the victim has uncontrolled twitching. Examples of organophosphate and carbamate insecticides used in Nebraska are listed in *Table III*. Some are being phased out or are not used as much as other insecticides.

Table III. Organophosphate and carbamate insecticides that have been or currently are used in Nebraska. Examples of trade names are in parentheses.

Organophosphates			Carbamates
Acephate (Orthene®)	Dimethoate *(Cygon)* (DeFend)	Phorate (Thimet®)	**Aldicarb (Temik®)*
Azinphos-methyl (Guthion®)	Disulfoton (Di-Syston®)	Phosmet (Imidan®)	Carbaryl (Sevin®)
Chlorpyrifos (Lorsban®)	Ethoprop (Mocap®)	Pirimiphos-methyl (Actellic)	***Carbofuran (Furadan®)*
Coumaphos (Co-Ral®)	Malathion	Terbufos (Counter®)	Methomyl (Lannate®)
Diazinon	Methyl Parathion (Penncap-M®)	Trichlorfon (Dylox®)	Propoxur *(Baygon®)*
Dichlorvos (Vapona®, DDVP®)	Naled (Dibrom®, Trumpet®)		

*Registrations for italicized products have been discontinued or will be soon after this publication is printed. The product still may be in an applicator's storage, so names are listed in the tables.
**Registration of this product has been discontinued, and it must not be used after December 31, 2013.

The effects of these materials, particularly organophosphate insecticides, are rapid. Signs and symptoms begin shortly after exposure, and in cases of acute poisonings, during exposure. Exposure to either of these insecticide classes may pose special risks to people with reduced lung function, seizures, or other conditions. In some cases, consumption of alcoholic beverages may worsen the effects of the pesticide.

The onset of symptoms in milder exposures usually occurs within 4 hours, but can occur up to 12 hours after exposure. Diagnosis of a suspected poisoning must be rapid. Signs and symptoms associated with mild exposures to organophosphate and carbamate insecticides include headache; fatigue; dizziness; loss of appetite with nausea, stomach cramps, and diarrhea; blurred vision associated with excessive tearing; contracted pupils; excessive sweating and salivation; slowed heartbeat, often less than 50 beats per minute; and rippling of surface muscles just under the skin. Some of these symptoms may be mistaken for those of flu, heat stroke, heat exhaustion, or an upset stomach.

Moderately severe organophosphate and carbamate insecticide poisoning cases exhibit all the signs and symptoms found in mild poisonings listed above. In addition, a victim may be unable to walk, complain of chest discomfort and tightness, have marked pinpoint pupils, exhibit muscle twitching, and have involuntary urination and bowel movement. Signs of severe poisonings include incontinence, unconsciousness, and seizures.

The order in which these symptoms appear may vary, depending on how contact is made with the pesticide. If the product is swallowed, stomach and other abdominal manifestations commonly appear first; if it is absorbed through the skin, gastric and respiratory symptoms tend to appear at the same time.

Fortunately, good antidotes are available for victims of organophosphate or carbamate poisoning at emergency treatment centers, hospitals, and many physicians' offices. As with all pesticide poisonings, prompt assistance is critical. If a pesticide is swallowed, obtain prompt medical treatment. If dermal exposure has occurred, remove contaminated clothing, wash exposed skin, and seek medical care.

Organochlorine Insecticides

The U.S. EPA has sharply curtailed the availability of many organochlorines because they persist in the environment. Organochlorines are formed from carbon and chlorine; examples include DDT, chlordane, dieldrin, aldrin, and lindane. Although few are available for purchase or registered for use, some organochlorine insecticides still may be present in storage areas. In addition, organochlorines, such as pesticides, dioxins, and polychlorinated biphenyls (PCBs), are in the environment due to drift from application, spills, leaks, and improper disposal of industrial wastes. Because of the persistence of organochlorines, traces of them still can be found in sediment, water, and living organisms, even though most use was banned in the U.S. decades ago. Some areas have advisories limiting the consumption of fish and shellfish due to the presence of these materials in their tissue. When fish and shellfish such as crabs and mollusks eat, they accumulate pollutants such as organochlorines and heavy metals present in their food, in tainted sediment, or water they filter to get food. The process called bioaccumulation or bioconcentration describes how pollutants accumulate or concentrate in living tissue. The potential for bioaccumulation increases as you go up the food chain, from tiny fish with organochlorines, eaten by larger fish, eaten by larger fish, eaten by humans.

Organochlorines affect the nervous system as stimulants or convulsants. Nausea and vomiting commonly occur soon after ingesting organochlorines. Other early signs and symptoms include apprehension (feelings of suspicion or fear of the future), excitability, dizziness, headache, disorientation, weakness, a tingling or pricking sensation on the skin, and twitching muscles. Loss of coordination, convulsions similar to epileptic seizures, and unconsciousness often follow. When chemicals are absorbed through the skin, apprehension, twitching, tremors, confusion, and convulsions may be the first symptoms. Chronic exposure may lead to cancer, birth defects, and mutations of genes.

No specific antidotes are available for organochlorine poisoning. People assisting a victim should wear chemical-resistant gloves and be careful to avoid contamination by the pesticide. Remove contaminated clothing immediately and bathe and shampoo the person vigorously with soap and water to remove pesticide from the skin and hair. If the pesticide has been swallowed, empty the stomach as soon as possible by giving the conscious patient syrup of ipecac and water or by inserting a clean finger into the throat while the victim is turned to one side, facing the floor. Never induce vomiting when a victim is unconscious: inhaling vomit may cause suffocation.

Pyrethroid Insecticides

Pyrethroids are synthetically produced compounds that mimic the chemical structure of naturally occurring pyrethrins found in a specific type of chrysanthemum plant. As with organophosphates and carbamates, pyrethroids affect the insect's nervous system, but in a different way: they are not cholinesterase inhibitors. Some examples of pyrethroids are listed in *Table IV*.

Table IV. Pyrethroid insecticides, with trade names for some products in parentheses.

Allethrin (Sniper®)	Fenvalerate (Evercide®)
Baythroid (Baythroid®, Discus®)	Fluvalinate (Mavrik® Perimeter)
Cyfluthrin (Tempo®)	Permethrin (Pounce®, Ambush®)
Cypermethrin (Barricade®)	Resmethrin (Rid®, Mosquito Beater®)
Deltamethrin (Battalion®)	Tetramethrin (aero® Assault)
Esfenvalerate (Asana® XL)	Tralomethrin (Dead-Fast® Insecticide Chalk)

Risk of poisoning by pyrethroids through inhalation and dermal absorption is low. Very few poisonings of humans by pyrethroids have been documented. Dermal contact may result in skin irritation such as stinging, burning, itching, and tingling progressing to numbness. Some people experience a range of allergic reactions from pyrethroids. Repeated exposures may increase the intensity of the reaction.

Although some pyrethroids may be toxic by the oral route, ingestion of this type of insecticide usually presents relatively little risk. Occasionally, a large dose may cause loss of coordination, tremors, salivation, vomiting, diarrhea, and irritability to sound and touch. Most pyrethroids are promptly excreted by the kidneys.

Biological Insecticides

Insecticides produced from plant materials or bacteria are called biological insecticides.

Azadirachtin, derived from the Neem tree, is an insect growth regulator that interferes with the insect molting process. For humans, exposure to azadirachtin causes slight skin and gastrointestinal irritation. Stimulation and depression of the central nervous system also have been reported.

Eugenol is derived from clove oil and used both as an insect attractant and insecticide. In humans, large doses can cause skin burns. Extremely large doses may result in liver problems and coma.

Pyrethrum and pyrethrins. Pyrethrum is found in the flowers of *Chrysanthemum cinerariaefolium*. Crude pyrethrum is a dermal and respiratory allergen for people. Skin irritation and asthma have occurred following exposures. Refined pyrethrins are less allergenic, but appear to retain some irritant and/or sensitizing properties.

In cases of human exposure to commercial pyrethrum products, realize that other toxicants may be present and will be listed on the label. Synergists may be added to insecticide products to enhance the killing power of the active ingredient. Synergists such as piperonyl butoxide, discussed later, have low toxic potential in humans, but organophosphates or carbamates included in the product may have significant toxicity. Pyrethrins themselves do not inhibit the cholinesterase enzyme.

Rotenone is a naturally occurring substance found in several tropical plants. Until 2011, it was formulated as dusts, powders, and sprays for use in gardens and on food crops. The Agriculture Health Study, involving 90,000 applicators and spouses from Iowa and North Carolina, showed a relationship between exposure to rotenone and the incidence of Parkinson's disease. More research is needed to reach any conclusions on the specifics of that relationship. Manufacturers of rotenone have voluntarily stopped producing the pesticide for all uses except the management of undesirable fish species. Rotenone is now a restricted use pesticide.

Antibiotics include abamectin, ivermectin, *Bacillus thuringiensis* (Bt), spinosad, and streptomycin. These compounds are practically nontoxic to humans. In studies involving deliberate ingestion by human subjects, slight inflammation of the gut occurred. Antibiotic insecticides in the form of emulsifiable concentrates may cause slight to moderate eye irritation and mild skin irritation due to the solvent carriers. Antibiotic pesticides are different from antibiotics taken by people to cure bacterial infections.

Inorganic Insecticides

Boric acid and borates. Boric acid, derived from borax and usually combined with an anti-caking agent, is commonly used to kill cockroaches. It can be harmful to humans if accidentally ingested. Avoid inhaling the dust during application. Inhaled borax dust causes irritation of the respiratory tract and shortness of breath. Borax dust is moderately irritating to skin. Infants have developed a red skin rash that most often affects the palms, soles of the feet, buttocks, and scrotum in severe poisonings. The skin developed a "boiled lobster appearance" followed by extensive skin peeling.

Diatomaceous earth (DE) is mined from the fossilized silica shell remains of diatoms, which are microscopic sea animals. Labels may refer to this ingredient as silicon dioxide, or "silicon dioxide from diatomaceous earth." DE is used commercially to control crawling insects, such as cockroaches, ants, and insects that infest grain. It is virtually nontoxic to humans. Avoid inhaling diatomaceous earth, however, as it can irritate the eyes and lungs.

Silica gel is a nonabrasive, chemically inert substance used as a dehydrating agent because the small particles absorb moisture and oils. Avoid inhaling the dust. Some grades of diatomaceous earth contain small amounts

of crystalline silica, which is known to cause a respiratory disease called silicosis and cancer. The risk of cancer depends on the duration and level of exposure. Pesticide-quality diatomaceous earth and silica gel are amorphous (non-crystalline), and do ***not*** cause silicosis or cancer.

Sulfur is moderately irritating to skin and has been associated with skin inflammation. Dust is irritating to the eyes and respiratory tract. If swallowed, it acts like a strong laxative.

Other Insecticides

Fluorines. Sulfluramid (Spectracide terminate® and Firstline®) is formulated as an ant, roach, or termite bait and is slightly irritating to the skin. Sulfluramid has low toxicity in lab tests. However, with repeated exposure, it has caused developmental abnormalities in young laboratory animals and affected the reproductive systems of male laboratory animals.

Nicotinoids, sometimes called **neonicotinoids,** were introduced in the 1990s. They are chemically similar to nicotine. They have a lower toxicity to humans than organophosphates and carbamates. Imidacloprid and thiamethoxam are used to control termites, turf insects, and some crop insects.

Farm workers reported skin or eye irritation, dizziness, breathlessness, confusion, or vomiting after they were exposed to pesticides containing imidacloprid. Similar symptoms, along with increased heart and breathing rates, also were noted after a victim ingested a product containing imidacloprid; the victim suffered severe cardiac toxicity and death 12 hours after oral exposure.

Pyrazoles. Fipronil is a moderately toxic pyrazole that may cause mild irritation to the eyes and skin. It is used to control termites (Termidor®, Taurus™), cockroaches (Combat®, Maxforce®), certain insect pests of corn, and fleas and ticks of cats and dogs (Frontline®, Effipro®, PetArmor™). Lab animals exhibited reduced feeding, reduced urination, increased excitability, and seizures following a toxic oral dose. After ingesting fipronil, humans have reported sweating, nausea, vomiting, headaches, abdominal pain, dizziness, agitation, and weakness. Direct, short-term contact with skin can result in slight skin irritation. Inhalation or dermal contact while spraying fipronil for five hours may have caused a person to have a headache, nausea, dizziness, and weakness. Symptoms developed two hours after spraying and then disappeared. According to the National Pesticide Information Center, signs and symptoms from a brief exposure to fipronil generally improve and clear up without treatment (*http://npic.orst.edu/factsheets/fipronil.pdf*).

Pyrroles. Chlorfenapyr (Phantom®, Pylon®) is the only product in this group. It is formulated to control ants, cockroaches, termites, and some insect and mite pests on fruits and vegetables. It is slightly toxic if swallowed or if it contacts the skin, and can be moderately irritating to eyes and skin.

Tetronic acids. Spiromesifen is the sole insecticide in this group. It is used to control mites and whiteflies on some vegetable crops (Oberon®) and ornamental trees (Forbid™, Judo™, Oberon®). No indication of eye irritation has been reported.

Tetramic acids. Spirotetramat (Kontos®, Movento®) is a systemic insecticide that controls a number of major sucking insects and mites that are pests of trees, vegetables, potatoes, and other plants. Some products with tetramic acids may cause moderate eye irritation. Prolonged or repeated skin contact may cause allergic reactions in some individuals.

Insect Growth Regulators

Insect growth regulators (IGR) act on insects in different ways. Those that mimic juvenile hormones keep insects in immature stages and prevent insect reproduction. Chitin synthesis inhibitors prevent insects from molting and growing into adults. In general, IGRs are very low in toxicity and cause mild skin irritation with limited exposure. No human poisonings or adverse reactions in exposed workers have been reported. Some examples of insect growth regulators are listed in *Table V*.

Table V. Common insect growth regulators. Examples of trade names are in parenthesis.

Diflubenzuron (Adept®, Clarifly®)	Methoprene (Bio Spot®)
Hexaflumuron (Shatter™)	Noviflumuron (Recruit®)
Hydroprene (Gentrol®)	Pyriproxyfen (First Shield™)

Mosquito Repellents

Diethyltoluamide (**DEET**) was developed by the U.S. Army in 1946 as an insect repellent and has been available to the general public since 1957. Products containing DEET (Detamide®, OFF!®) have been effective and generally well tolerated when applied to human skin. If left on skin for an extended period, some people have experienced irritation, redness, a rash, and swelling. Tingling and mild irritation have occurred following repeated application. In some cases, DEET has caused skin irritation and worsened preexisting skin disease. It is very irritating to the eyes but not corrosive. When swallowed, it has caused nausea and vomiting.

Serious adverse effects have occurred when DEET was used under hot, humid conditions and not washed off before going to sleep. The skin became red and tender, then blistered and formed ulcers, leaving painful

weeping bare areas that were slow to heal. Permanent scarring resulted from most of these severe reactions. Very rarely, seizures in people have been associated with exposure to DEET. Most have occurred after drinking products with DEET or using the products in ways that do not follow label directions.

Exercise great caution when using DEET on children: only use products containing lower concentrations. The American Academy of Pediatrics (AAP) recommends against using any repellent on infants 2 months of age or younger. The AAP cautions parents not to use DEET on the hands of a child and to avoid applying it to areas around a child's eyes and mouth. Consider applying DEET only to clothing, using as little repellent as possible. If a child experiences a headache or any kind of emotional or behavioral change, discontinue the use of DEET immediately. Limited information is available on childhood responses to DEET from research or Poison Control Center reports. Most adverse responses were the result of improper use or accidents.

Picaridin, a synthetic compound first made in the 1980s, resembles a natural compound found in the group of plants used to produce black pepper. Although widely used as an insect repellent in Europe and Australia, picaridin has been available in the United States only since 2005. Although uncommon, some people have experienced skin irritation. Picaridin also may cause irritation if it gets into a person's eyes. Rats lost weight and their kidneys were affected when fed large doses of picaridin. The material is considered practically nontoxic if inhaled. While children may be especially sensitive to pesticides compared to adults, no data suggest that children have increased sensitivity specifically to picaridin.

Oil of Citronella has been used for over 50 years as an insect and animal repellent. It is found in many familiar insect repellent products, including candles, lotions, gels, sprays, and towelette wipes. These products vary in effectiveness and may repel various insects, such as mosquitoes, biting flies, and fleas. When used according to the label, citronella products are not expected to harm humans, pets, or the environment. The only concern in studies involving laboratory animals is skin irritation. The EPA requires precautionary labeling because some citronella products are applied to human skin. Citronella is not expected to pose health risks to people, including children and other sensitive populations, if used according to label instructions.

Fumigants

Fumigants deliver the active ingredient to the target site in the form of a gas. Fumigants can completely fill a space, and many have tremendous penetrating power. They can be used to treat objects such as furniture, structures, grain, and soil for insect pests and other vermin. Fumigants are among the most hazardous pesticide products to use due to danger of inhalation.

Various fumigants produce differing physiological effects. Headache, dizziness, nausea, and vomiting are common early signs and symptoms of excessive exposure.

Prompt medical treatment is critical with fumigant poisoning. Immediately move a victim of fumigant inhalation to fresh air. Keep the individual quiet in a semi-reclining position even if initial signs and symptoms are mild. If breathing has stopped, give mouth-to-mouth or mouth-to-nose resuscitation. If the victim has no pulse, immediately give cardiopulmonary resuscitation (CPR) using chest compression. Some fumigant products, along with signs and symptoms of poisoning, are listed below.

Chloropicrin causes severe irritation of the upper respiratory tract, eyes, and mucous membranes. Symptoms of exposure to chloropicrin include burning eyes, tearing, coughing, difficulty breathing, headaches, nausea, and vomiting. Chloropicrin may be a stand-alone fumigant or may be combined with other fumigants to increase their potency. When present in low percentages, it serves as a warning agent.

Sulfuryl fluoride (Vikane®) poisoning symptoms include depression, slowed walking pattern, slurred speech, nausea, vomiting, stomach pain, stupor, itching, numbness, twitching, and seizures. Inhalation of high concentrations may irritate the respiratory tract and may be fatal due to respiratory failure. Sulfuryl fluoride almost always is applied with chloropicrin, so the first signs of poisoning are often associated with severe irritation of the eyes and mucous membranes. Skin contact with gaseous sulfuryl fluoride normally poses no hazard, but contact with liquid sulfuryl fluoride can cause pain and frostbite due to cold temperatures from rapid evaporation.

Phosphine fumigants, such as aluminum and magnesium phosphide (Phostoxin®, PhosFume®, Fumitoxin®, and Fumi-Cel®) affect cell function in the liver and lungs. Mild exposure is signaled by a sensation of cold, chest pains, diarrhea, and vomiting. Exposures that are somewhat more serious will be evidenced by cough, tightness in the chest, difficulty in breathing, weakness, thirst, and anxiety. Signs and symptoms of severe exposure include stomach pain, loss of coordination, blue skin color, pain in limbs, enlarged pupils, choking, fluid in the lungs, and stupor. Severe poisonings can lead to seizures, coma, and death.

Methyl bromide (Metabron, Meth-O-Gas®) affects the central nervous system, lungs, heart, and liver. People poisoned by methyl bromide experience the common

signs and symptoms of fumigant poisoning along with abdominal pain, weakness, slurred speech, mental confusion, muscle twitching, and convulsions similar to epileptic seizures. Some liquid fumigants cause skin injuries indicated by areas of redness or blisters that rupture, leaving raw skin or deep ulcers. There are few registered uses of methyl bromide: those remaining are on a conditional year-by-year basis.

Acrolein (Magnacide H®) is an extremely irritating gas used as an aquatic herbicide. Inhalation of the vapor causes irritation in the upper respiratory tract, which may lead to a buildup of fluids in and narrowing of the air passages. If ingested, it attacks the stomach lining, resulting in open sores and cell death. Contact with skin may cause blistering.

Dazomet (Basamid® G) is a granular soil fumigant. It is used to sterilize soil to eliminate weeds, nematodes, and soilborne diseases. Dazomet is highly toxic if swallowed and can be fatal. Frequent or prolonged exposure to skin can result in irritation or more serious skin problems for some individuals. Inhalation can cause a variety of acute and chronic lung conditions, including local irritation, inflammation, fluid buildup, and lung disease.

Metam sodium (Vapam®) is a soil fumigant used to kill fungi, bacteria, weed seeds, nematodes, and insects. When combined with water, it produces a gas that is very irritating to respiratory mucous membranes, eyes, and lungs. Inhalation can cause severe respiratory distress, including coughing of blood and frothy sputum. It can only be used outdoors, and precautions must be taken to avoid inhaling the gas.

Dichloropropene (Telone®) is very irritating to skin, eyes, and the respiratory tract. Inhalation may cause spasms of the bronchi, where air passes into the lungs. Although limited data for humans exist, animals have experienced liver, kidney, and cardiac toxicity. Most dichloropropene products contain chloropicrin; severe irritation of the eyes and mucous membranes is an early sign of exposure. Apparently, risk for oral toxicity is low for humans unless large quantities of dichloropropene are ingested.

Rodenticides

Pesticides designed to kill rodents pose particular risks to humans. Since they are designed to kill mammals, their mode of action is toxic to humans as well. In addition, rodents often live near humans and other mammals, so accidental exposure to baits is a risk. In the effort to make more effective rodenticides, more toxic materials have been developed, increasing the risk to humans. Symptoms from ingestion of rodenticides can be delayed for days — up to four days for bromethalin, and up to seven days for anticoagulants.

Benzenamines. Bromethalin (Tomcat®), the only chemical in this class of rodenticide, is not an anticoagulant (substance that slows clotting of blood). Instead, it acts on the central nervous system. Possible signs and symptoms of exposure to this compound include skin and eye irritation, headache, confusion, muscle twitching, convulsive seizures, and difficulty breathing. Bromethalin poisoning in dogs usually results in paralysis or convulsions and sometimes swelling or bloating of the abdomen.

Coumarins are anticoagulants: they slow the ability of blood to clot and disrupt capillary and liver function. Examples include brodifacoum (Jaguar®, Talon®, WeatherBlok®, now d-CON®), bromadiolone (Contrac®, Maki®), and warfarin (Kaput®, formerly d-CON®). The main signs and symptoms are nosebleeds, bleeding gums, blood in the urine, tar-colored feces, and large irregular blue-black to greenish-brown spots on the skin. Vitamin K is an antidote.

Indandiones also are anticoagulants. Examples are chlorophacinone (Rozol®) and diphacinone (Ditrac®, Ramik®). Main signs and symptoms are similar to coumarin compounds, but some indandiones cause nerve, heart, and blood system damage in laboratory rats, leading to death before hemorrhage occurs. None of these signs and symptoms have been reported in poisonings of humans. Vitamin K is an antidote.

Strychnine is not easily absorbed through the skin nor does it accumulate in the human body. When ingested, however, it acts on the central nervous system within 10 to 30 minutes. Convulsions — violent seizures with involuntary jerky movements that cause the victim to stop breathing — also can occur. Treatment of strychnine poisoning is geared toward eliminating outside stimuli. If strychnine poisoning occurs, place the victim in a warm, dark room to reduce outside stimuli that trigger convulsions. Consequently, in the case of strychnine poisoning, bring medical help to the victim rather than transporting the victim to a medical center, because movement will trigger the convulsions.

Zinc phosphide causes severe irritation if ingested. It reacts with water and stomach juices to release phosphine gas, which enters the blood stream and affects the lungs, liver, kidneys, heart, and central nervous system. Zinc phosphide can be absorbed through the skin and inhaled from fumes. With repeated exposure, it accumulates in the body to dangerous levels. Signs and symptoms of mild zinc phosphide poisoning include diarrhea and stomach pains. In more severe cases, nausea, vomiting, chest tightness, excitement, coldness, loss

of consciousness, coma, and death can occur from fluid buildup in the lungs and liver damage. No antidote for zinc phosphide poisoning exists. It is a slow-acting material, which allows time to get the victim medical assistance.

Wood Preservatives

Pesticides registered as wood preservatives extend the life of wood by reducing or preventing the establishment of populations of organisms such as fungi that cause rot or insects that degrade the wood. Some preservatives can leach slowly into the surrounding soil or water. Sometimes, touching treated wood can leave residue on exposed skin.

Creosote (coal tar) typically is found on railroad ties that sometimes are used for landscaping. Exposure can cause skin irritation and prolonged exposure may lead to inflamed skin. Vapors and fumes of creosote are irritating to the eyes and respiratory tract. Ingested creosote may result in severe liver damage. Creosote is considered a probable human carcinogen. Creosote-treated wood cannot be used in residential settings; it may only be used in commercial applications.

Pentachlorophenol (PCP, Penchlorol, Penta, Dura-treat®), typically used on utility poles or fence posts, is irritating to the eyes, skin, and respiratory tract. It can cause a stuffy nose, scratchy throat, and tearing eyes. Prolonged exposure sometimes leads to an acne-like skin condition. Ingestion of PCP solutions, excessive skin contact, or inhalation of concentrated vapors may cause fever, headache, weakness, dizziness, nausea, and profuse sweating. Extreme cases of exposure can lead to a loss of coordination and seizures, high fever, muscle spasms and muscle twitching, difficulty breathing, a sense of tightness in the chest, abdominal pain and vomiting, restlessness, excitement, and mental confusion. Intense thirst also is a characteristic. Pentachlorophenol poisoning can be fatal.

Arsenical wood preservatives such as chromated copper arsenate (CCA) and ammoniacal copper arsenate (ACA) were used extensively in the past to treat construction lumber for decks, play sets, and fence posts. CCA is not well absorbed through the skin, but hand-to-mouth contact can result in exposures. If swallowed, arsenicals can cause nausea, headache, diarrhea, and abdominal pain. Extreme signs and symptoms can progress to dizziness, muscle spasms, violent mental agitation, and seizures. Prolonged exposure to arsenical wood preservatives can result in persistent headaches, abdominal distress, salivation, low-grade fever, and upper respiratory irritation.

Herbicides

Herbicides kill weeds by affecting metabolic processes in plants. Therefore, risk to humans and other mammals is relatively low. Some herbicides, however, can pose a risk of poisoning if not handled according to label directions. Regardless of their chemical structure, the vast majority of herbicides often affect the human body in a similar way. In general, they can irritate the skin, eyes, and respiratory tract. Always read and follow label recommendations carefully to avoid any of these health risks. Herbicides that present the greatest potential health risks are covered in the next four sections.

Bipyridyl Herbicides

Diquat and **paraquat** are the most common bipyridyl herbicides. Paraquat is more toxic than diquat and produces chronic abnormal cell growth in the lungs, cornea and lens of the eyes, nasal mucous membranes, skin, and fingernails. Diquat affects the eye lens and intestinal tract lining but usually does not produce the frequently fatal lung changes characteristic of paraquat.

Ingesting diquat or paraquat causes severe irritation to the mucous membranes of the mouth, esophagus, and stomach. Repeated vomiting generally follows. Large doses of diquat also produce restlessness and reduced sensitivity to stimulation. Large doses, and sometimes even small doses, of paraquat initially can affect the kidneys, liver, adrenal glands, and lungs: potentially fatal fluid accumulation in the lungs can occur in 24 to 72 hours.

Lesser amounts of paraquat will cause decreased urine output because of kidney failure. Yellowing of the skin due to liver damage is sometimes observed. This initial phase is followed by an inactive period lasting up to two weeks, during which the victim appears to improve. The victim, however, may have permanent and gradually advancing lung damage caused by rapid growth of connective tissue. This prevents proper lung function and eventually leads to death through respiratory failure. Paraquat selectively concentrates in cells in the lungs.

Skin exposure to paraquat and diquat concentrates may cause severe skin irritation and burning. Contact with dilute liquids and diquat dusts may cause slight to moderate irritation. Skin absorption of paraquat apparently is slight. Diquat, however, is absorbed and after repeated contact will produce symptoms similar to those following ingestion.

Exposure to paraquat and diquat spray mist may produce skin irritation, nasal bleeding, irritation and inflammation of the mouth and upper respiratory tract, coughing, and chest pain. Exposure to paraquat concentrates may cause nails to blacken and grow abnormally.

No specific antidotes are available to counteract the effects of paraquat, diquat, and other bipyridyl

herbicides once significant exposure and absorption has occurred. Seek medical attention promptly. If ingested, and the victim is conscious, induce vomiting immediately unless a physician advises not to. Flush affected eyes with water, and wash skin with soap and water.

Chlorophenoxy Herbicides

2,4-D and MCPA are examples of chlorophenoxy herbicides. These compounds are moderately irritating to skin and mucous membranes. Inhalation may cause a burning sensation in the nose, sinuses, and chest, which may result in coughing. Prolonged inhalation sometimes causes dizziness.

Stomach irritation usually leads to vomiting soon after ingestion. Victims may experience chest and abdominal pain and diarrhea. Headache, mental confusion, and bizarre behavior are early signs and symptoms of severe poisoning, which may progress to unconsciousness.

Arsenical Herbicides

Ansar®, Montar®, MSMA, and **cacodylic acid** are some examples of arsenical herbicides. Acute arsenic poisoning usually appears within one hour of ingestion. Garlic odor of the breath and feces may help to identify the responsible toxicant in severe cases. Effects on the digestive tract include inflammation of the mouth and esophagus, burning abdominal pain, thirst, vomiting, and bloody diarrhea.

Arsenic may affect the central nervous system as well. Effects include headache, dizziness, muscle weakness and spasms, low body temperature, sluggishness, delirium, seizures, and coma. Liver damage may lead to yellowness of the skin. Injury to tissues that form blood may cause a reduction in red and white blood cells and blood platelets. Death usually occurs one to three days after the onset of symptoms and is usually the result of circulatory failure.

Chronic arsenic poisoning through skin exposure usually is more of a problem than acute poisoning, characterized by effects in the intestinal tract. Chronic arsenic poisoning may result in cancer. Symptoms of chronic exposure include overgrowth of the eye's cornea; scaling off of dead skin; excessive fluids under the skin of the face, eyelids, and ankles; white streaks across the nails; loss of nails or hair; and brick red coloration of visible mucus membranes.

Other Herbicides

Endothall (Aquathol®) is commonly used as an aquatic herbicide or algaecide. It is irritating to skin, eyes, and mucous membranes. In one case, a man died after ingesting endothall. In this case, bleeding and swelling were noted in the gut and the lungs.

Sodium chlorate (Drexel®, Defol®) is used as a defoliant, nonselective herbicide, and soil sterilant. It is irritating to skin, eyes, and stomach. Even though sodium chlorate is poorly absorbed in the digestive tract, ingestion of a large dose will cause severe poisoning. Irritation to the gut causes nausea, vomiting, and abdominal pain. Bluish skin sometimes is the only visible sign of poisoning. Dark brown staining of the blood and urine can indicate sodium chlorate poisoning.

Fungicides

Fungicides are used extensively in industry, agriculture, and the home and garden. Fungicides vary in their potential for causing adverse effects in humans. According to the EPA manual, *Recognition and Management of Pesticide Poisoning* (Morgan, 1999), "… most fungicides currently in use are unlikely to cause frequent or severe systemic poisonings for several reasons. First, many have low inherent toxicity in mammals and are inefficiently absorbed. Second, many fungicides are formulated as suspensions of wettable powders or granules, from which rapid, efficient absorption is unlikely. And third, methods of application are such that relatively few individuals are intensively exposed." Fungicides probably have caused a large number of irritant injuries to skin and mucous membranes, as well as some skin sensitization. As with any pesticide, always read and follow label recommendations carefully to avoid any health risks that a specific fungicide may pose.

Other Pesticides and Synergists

The three chemicals listed in this section are among the many pesticides and synergists that have not been discussed. These are listed because they have a relatively high potential for harming humans and nontarget animals.

4-aminopyridine (Avitrol®) is a highly toxic powder used as a bird repellent, often mixed with whole or cracked corn. It is toxic to all vertebrates. No human poisonings have occurred when used according to label directions. However, intentional ingestion has resulted in immediate abdominal discomfort, nausea and vomiting, weakness, dizziness, profuse sweating, and, sometimes, death.

Metaldehyde (Deadline®) has been used to control slugs and snails for many years. Poisoning of animals (particularly dogs) and children occurs occasionally when metaldehyde is swallowed. Ingestion of a toxic dose often is followed by nausea and vomiting, then fever, seizures, and changes in mental status, sometimes leading to coma. Other signs and symptoms that can occur

are excessive salivation, facial flushing, dizziness, rapid breathing, and high acidity in the blood. While most poisonings are dramatic, they are rarely fatal. Deaths of dogs are common, however, when they eat enough of the product.

Piperonyl butoxide (PBO) is not a pesticide but one of the most common synergists in use. Synergists typically are added to insecticide products to enhance the effectiveness of the active ingredient. For example, PBO slows the ability of an insect to break down a pesticide. If PBO was not added to a particular insecticide, the insect could break down the pesticide before it could have an effect. As a synergist, PBO reduces the amount of a pesticide that is needed to be effective. Toxicity of PBO in mammals is low, although based on limited evidence of cancer in laboratory animals, it was considered a possible human carcinogen. PBO may trigger allergic responses in some people. Another common synergist that works the same way is known by either MGK 264 or n-octyl bicycloheptene dicarboximide.

What if a Pesticide Poisoning Occurs?

The key to surviving and recovering from a pesticide poisoning is ***rapid*** treatment. **Take emergency action immediately when you suspect a pesticide poisoning has occurred.** As time elapses after exposure, the toxic effects are heightened, and the victim may need more time to recover.

Immediately dial **911** whenever you suspect a pesticide poisoning. An advanced life support team will be dispatched to provide assistance. In addition, you may wish to contact the following:

1. **The Poison Control Center (800-222-1222)** will provide specific directions on procedures to follow until a life support team arrives.
2. The nearest hospital or a physician. These can benefit by having preliminary information before the patient arrives.
3. Another source of medical and consumer information related to pesticides during nonemergencies is the National Pesticide Information Center (**800-858-7378** or online at *http://npic.orst.edu*).

What a victim might think is a cold or the flu could be a fatal pesticide poisoning. Whenever possible, get answers to the following questions.

1. Has the victim been exposed to a pesticide?
2. If so, which one and how did the exposure occur?
3. What emergency actions are given on the pesticide label?

Many pesticide labels direct that vomiting be induced. You can do this by giving the patient syrup of ipecac and water or by inserting a clean finger into the throat of the victim. **Do not induce vomiting when:**

- the label says not to,
- the victim is having or has had seizures accompanied by involuntary jerking movements,
- the victim is unconscious, or
- the pesticide contains petroleum products such as xylene.

Caution: Inhaling vomit can be life-threatening. Timely emergency treatment is vital to survival.

After exposure to a pesticide, always wash the victim's exposed skin with soap or detergent and plenty of water, then obtain medical treatment. Skin irritation can result from continuous exposure if not treated. If the victim's clothing has been contaminated by a pesticide that is readily absorbed by the skin, remove the clothing and wash or rinse the victim's skin.

Remember to protect yourself as you help the victim. Wear chemical-resistant gloves. If a pesticide spill is involved, move the victim away from the spill. Assist the victim first; take action to clean up the spill after all first aid has been completed.

Even though most people are careful when working with pesticides, accidents can happen. Be prepared. Keep the telephone number for the Poison Control Center readily available either in your telephone directory or near your telephone. Do not hesitate to contact medical authorities if any symptoms of pesticide poisoning occur. It is better to be safe than sorry.

Most pesticides used by Nebraska farmers, ranchers, and people with lawns and gardens have lower toxicity levels than many of the pesticides discussed in this publication. When applied properly, with the required protective clothing and equipment, they are unlikely to cause problems for the user. However, ***any*** pesticide ***can*** cause problems due to exposure or overexposure. **Use all pesticides safely. Federal and state laws require that you read the pesticide label completely and comply with all directions. Failure to do so may subject you to federal and/or state sanctions or penalties.**

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Pesticide Safety Telephone Numbers

Emergency Telephone Numbers **911**

Poison Control Center **800-222-1222**
For aid in human poisoning cases

Nebraska Department of Environmental Quality **402-471-2186 or 877-253-2603**
8 a.m. to 5 p.m. Central Time, Monday through Friday
To report chemical spills or releases after hours and holidays, contact the Nebraska State Patrol Dispatch.

Nebraska State Patrol Dispatch **402-471-4545 or 800-525-5555**

Nonemergency Telephone Number

National Pesticide Information Center **800-858-7378**
8:30 – 4:30 Mountain time, 9:30 – 5:30 Central time, Monday through Friday

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