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MontGuide

Assessing Pesticide Toxicity

by Cecil Tharp, Pesticide Education Specialist, Department of Animal and Range Sciences; and Jerome Schleier, Graduate Research Assistant, Department of Land Resources and Environmental Sciences

Pesticides are an essential tool for many pest management strategies across Montana. Perspectives vary as to the dangers that are posed by the use of these chemicals. This publication was created to aid applicators in understanding their pesticide's toxicological characteristics.

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PESTICIDES ARE AVAILABLE FOR CONTROLLING pests in a wide range of settings across Montana. At times individuals give these pesticides simple labels, such as 'safe' or 'dangerous', with little understanding of the true toxicological properties of the pesticide. These slang statements do not accurately quantify pesticide toxicity. The fact that many pesticides may be highly toxic towards humans with one large dose (acute toxicity) is undeniable. Other pesticides may be relatively non-toxic, or only cause slight irritation to the skin, eyes, nose or mouth from one relatively large dose. Still, other pesticides can be dangerous after many small, repeated exposures over an extended period of time (chronic toxicity). Low acute toxicity may be accompanied by high chronic toxicity and vice versa with the same pesticide. An understanding of how to interpret a pesticide's toxicity is critical prior to use. By understanding the toxicological properties of a pesticide, applicators can minimize risk to themselves and their families by wearing proper personal protective equipment (PPE) and following a relevant level of caution.

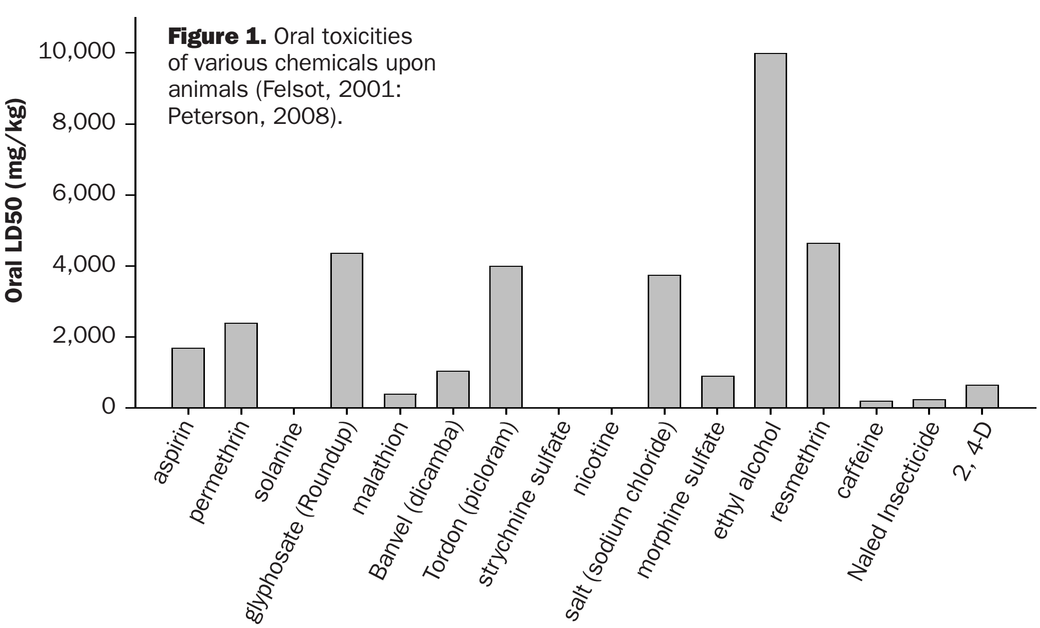

Figure 1. Oral toxicities of various chemicals upon animals (Felsot, 2001: Peterson, 2008).

Perspectives on Toxicity

Toxicity refers to the ability of a substance to produce adverse effects. Technically speaking, we are surrounded with toxic poisons on a daily basis. Many common foods, including coffee and potatoes, can be lethal at high enough doses (Figure 1). For instance, the amount of caffeine in 100 cups of coffee, or the amount of solanine in 10 pounds of green potatoes (including the skin) would constitute a lethal dose. Some chemicals we need to survive, such as vitamin D, become lethal at a dosage of 10 mg/kg. Vitamin A and B3 are also toxic at high enough levels. Are these foods and vitamins poisons? The answer is yes and no.

The awareness of chemicals in our environment has increased in recent years due to the development of sophisticated equipment which can measure pesticide presence in far lower concentrations than ever before. The mere presence of a pesticide in the environment may constitute an alarming report from the media with little acknowledgement of one basic toxicological principle. Over half a century ago, a fundamental truth of toxicology was born: the 'dose' makes the poison. Everything can be toxic, and everything can be benign, depending on the dose. Keep in mind that we are bombarded with many materials listed by the EPA as hazardous, including benzene, which is a natural constituent of gasoline. EPA has determined that although the average consumer is exposed to this hazardous agent, it is not at a 'dose' or level that would do harm and is far below any level of concern. For these reasons it is important to understand the exact dosage required to cause a health concern for each pesticide used, and any steps that can be taken to minimize risks.

Absorption/Individual Response

Pesticide toxicity is influenced by its absorption into the body and the corresponding characteristics of the exposed individual. Pesticides can enter the body through oral contact (ingestion); through dermal contact (the skin); through inhalation; or through ocular contact (the eyes).

Ingestion of a pesticide often occurs with children, but it may be the result of carelessness as well. Some examples of careless actions are blowing out a plugged nozzle with your mouth, smoking or eating while applying pesticides without first washing hands.

Dermal exposure accounts for 90 percent of the exposure applicators receive from pesticides. This may occur undetected while mixing, spraying or cleaning up. Absorption by the skin depends on the location of the pesticide on the body (Table 1), size of area contaminated, length of time on the skin and the amount of pesticide on the skin.

Inhalation exposure commonly results from application of dusts, fumigants, or other pesticide solutions which are easily airborne. Smaller particulates enter the lungs more easily, while larger particulates tend to lodge within the esophagus or nasal cavities. Once in the lungs, pesticides easily enter the blood stream inducing poisoning symptoms. Wearing a proper respiratory device as indicated on the pesticide label should eliminate inhalation poisoning if correctly used.

Ocular exposure may cause irreversible damage to the eyes. Ocular exposure is most often the result of splashing during mixing and cleaning while not wearing protective goggles. Contact lenses should never be worn during application of pesticides as they serve as a delivery mechanism for pesticides into the eyes.

Table 1. Parathion absorption rates through the skin on body regions over a 24 hour period. (Maiback and Feldman, 1974).

Body Region	Percent Relative Absorption
Forearm	8.6
Palm of Hand	11.8
Ball of Foot	13.5
Abdomen	18.4
Scalp	32.1
Forehead	36.3
Ear Canal	46.5
Genitalia	100.0

Individual characteristics which influence a pesticide's toxicity are:

- body size (larger individuals need more poison to cause an effect)
- health
- age (children and elderly tend to be more susceptible)
- gender (some pesticides work differentially toward each gender)
- genetic predisposition,
- habits (smoking, dietary, etc…)

Measuring Toxicity

A pesticide contains active (chemicals that kill the pest) and inert (solvents, carriers, dispersants, surfactants) ingredients. The EPA has mandated that all pesticide active ingredients be tested for acute and chronic mammalian toxicity, while all pesticide inert ingredients are tested for only acute mammalian toxicity. The toxicity of a pesticide is primarily measured with test animals including rats, rabbits, mice, guinea pigs and dogs. Human toxicity is extrapolated from these tests.

Acute Toxicity. The acute toxicity of a chemical refers to its ability to cause unwanted effects from one exposure. This is derived by applying various concentrations of pesticide to a test subject's eyes, skin, mouth and in the air the subject breathes. Data from these trials are converted into LD_{50} (lethal dose 50 percent) or LC_{50} (lethal concentration 50 percent) values. These values are the doses or concentrations at which 50 percent of the animals tested die. Lower values are more toxic than higher values. LD_{50} values are expressed in mg/kg (chemical weight/animal weight), while LC_{50} values are expressed in mg/l (chemical particles/air or water particles). For example, the insecticide malathion has an LD_{50} of 1,000 mg/kg (Figure 1), which means a dose of 1,000 mg of malathion per 1 kg body weight are lethal to half the test animals.

The acute LD_{50} or LC_{50} then fits into 1 of 4 toxicity categories based on the results of all acute oral, dermal, and inhalation tests. Each pesticide is given a signal word based on the toxicity category it falls in (Table 2). Signal words are:

- Danger "Poison" (Highly Toxic)
- Warning (Moderately Toxic)
- Caution (Slightly Toxic)
- Caution (Relatively Nontoxic)

No Observed Adverse Effect Level (NOAEL). LD_{50} values obtained are important in determining the relative toxicity of a pesticide product, although this serves as a poor threshold for determining acceptable risk. The 'No Observed Adverse Effect Level' (NOAEL) is also determined during toxicity testing studies. This is the highest dose that does not cause an adverse effect (Figure 2). The 'NOAEL' is used by risk assessors in determining occupational and dietary risks. Due

Table 2. Signal words found on product label.

Signal Word	Toxicity Rating	Oral LD_{50} (mg/kg)	Lethal Dose for 160 lb Human
DANGER[1]	Highly Toxic	0 — 50	Few drops to 1 Teaspoon
WARNING	Moderate Toxicity	50 — 500	1 Teaspoon to 1 Ounce
CAUTION	Slightly Toxic	500 — 5,000	1 Ounce to 1 Pint
CAUTION	Relatively Non-Toxic	> 5,000	Over 1 Pint

[1] Sometimes the word 'Danger' appears with the word 'Poison' for extremely toxic pesticides. Danger by itself usually relates to the pesticide's capacity to cause serious skin or eye injury.

to the potential differences between animals and humans, in addition to the uncertainties in the toxicity testing data, a safety factor is applied to the NOAEL. The NOAEL is divided by the safety factor to create the reference dose (RfD), which is used as the toxic endpoint in the assessment. In order to determine the risk, risk assessors estimate the dose/exposure of the chemical through computer simulations and field trials for different receptors (children, fish, etc.). To determine if the risk is acceptable, they bring together the dose/exposure and the toxic endpoint. If the dose/exposure exceeds the toxic endpoint the product either has restrictions placed on it, or the risk assessors estimate actual exposure in the field to humans and the environment. The risk assessment determines if the product, when used as directed by the label, presents negligible risk to humans and the environment.

Chronic Toxicity. A pesticide's chronic toxicity is also vital to understanding a pesticide's true toxic properties. Chronic toxicity refers to the adverse effects produced from repeated, long-term exposure to low doses of pesticides. Adverse effects may be delayed days, months, years, or a lifetime before becoming evident. Applicators commonly assume that a pesticide is 'safe' due to the low short-term toxicity (Signal Word: Caution) indicated on the product label. However, they may not be aware of the long-term risks associated with lack of personal protective equipment and unsafe application practices. The EPA currently mandates that all active ingredients be tested for chronic toxicity, and that warning statements regarding the findings of these studies be included on the product label.

Test animals are exposed to sub-lethal doses for a period of months to several years to obtain chronic toxicity estimates. Test animals are assessed for many reactions including:

- Carcinogenesis – cancer
- Teratogenesis – birth defects
- Mutagenicity – genetic changes
- Oncogenicity – tumors
- Reproductive – reproductive problems
- Nervous – nerve damage
- Immune – allergic reactions

Exact doses and duration of exposure to contract these toxic effects are difficult to predict. Chronic toxicity may not be recognized in applicators or workers who show symptoms months or years later.

Debate – "Agricultural Health Study"

Debate continues over the accuracy of chronic toxicity testing procedures. Currently, chronic toxicological information is based on tests on animals, generally over a short period of time (lifetime of a rat). In addition, inert ingredients are not mandated by EPA to be tested for chronic toxicity. The Agricultural Health Study is one of the first investigations to actually look in hindsight at associations between various pesticide applicators and adverse health effects observed years later. This investigation, which assessed over 90,000 certified pesticide applicators and their spouses, found a relationship between the use of certain pesticides and adverse health conditions that were not always indicated from previous EPA mandated toxicological tests. It should be noted that this study relies primarily on the memory of participants to determine dose related exposures, and hindsight investigations based on surveys are prone to personal bias. Keep in mind that an association indicated in the Agricultural Health Study

Figure 2. An example of a dose response curve indicating the "No Observable Adverse Effect Level" in relation to the LD_{50}

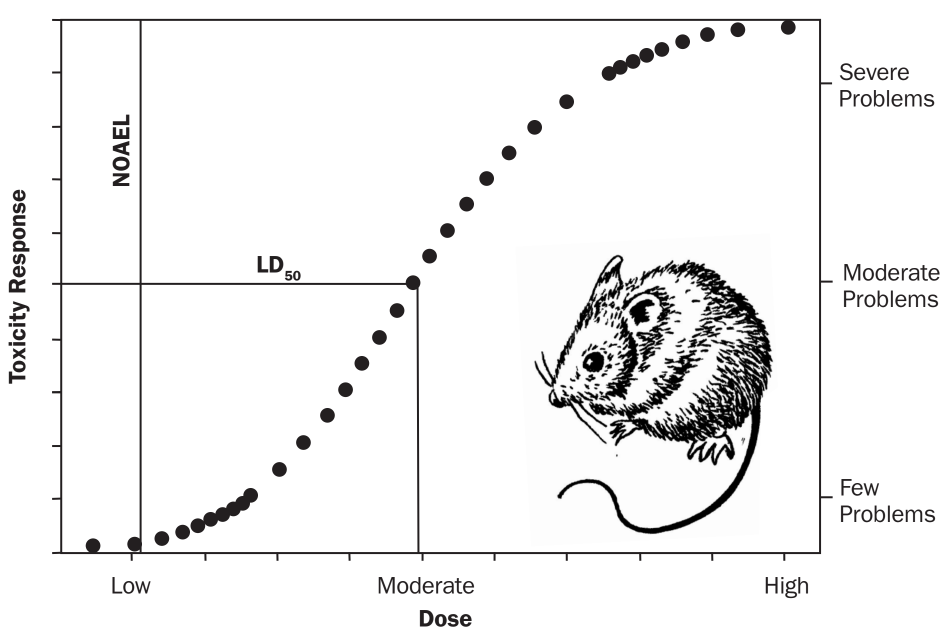

Table 3. Steps that should be taken to protect yourself from the inherent acute and chronic toxicity of your pesticide.

Action	Material	Phases	Protection of:
Gloves	Nitrile, viton, neoprene, vinyl, rubber	All phases	Dermal
Apron*	Chemically resistant	Mixing, Handling	Dermal
Coveralls*	*Tyvek, Tychem, Rubber	All phases*	Dermal
Goggles/Face Shield*	Chemically Resistant	All phases*	Ocular (eyes)
Respirator*	Variable*	All phases*	Respiratory/Ingestion
Wash hands after handling, while discarding pesticide contaminated clothing. Store pesticides in a safe, secure location away from children.			

*Always read the product label for specific directions regarding proper personal protective equipment.

does not imply cause and effect. Further studies are needed to indicate whether this hindsight investigation or previous toxicological tests should have premise. The take home message is that reading and following the product label will help minimize any unknown detrimental effects that may occur years later through long term misuse of pesticides.

Conclusions

Understanding a pesticide's toxicological properties is vital to minimizing risk toward you, fellow workers, pets and family members. Steps should be taken to protect yourself from the inherent acute and chronic toxicity of your pesticide (Table 3). Exaggerating a pesticide's toxicity can be equally undesirable. Reading the product label and understanding signal words, chronic toxicity statements, and proper personal protective equipment are three ways of achieving this balance. Debate within the scientific community may persist about the exact risks a pesticide may pose, but a common sense approach toward toxicity should prevail. Follow the product label and wear the amount of protection that is indicated on the label while following safe use practices.

References

Felsot, Allan S., *Assessing the Safety of Herbicides for Vegetation Management in the Missoula Valley Region.* Washington State University. Richland, WA. 10-13. April, 2001.

Maiback, Howard I. and Feldman, Robert, *Occupational Exposure to Pesticides.* Report to the Federal Working Group on Pest Management from the Task Group on Occupational Exposure to Pesticides, Washington, DC, 122-127. 1974.

Peterson, Robert J., *Biorisk Assessment.* Biological Risk Assessment 507. Montana State University, Bozeman. 27 September 2007.

Additional Resources

National Pesticide Information Center
(800) 858-7378 or http://npic.orst.edu/

Rocky Mountain Poison Control Center
(800) 525-5042 (Montana only)

Poison Information Center Network
(800) 222-1222 or http://www.fpicn.org

Pesticide Toxicity Hazard and Risk (866) 882-7677
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2375?opendocument

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