Understanding Pesticide Toxicity

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Introduction

Pesticides can be included as part of an integrated pest management (IPM) strategy, but they must be used with care and attention. Understanding how toxic a product is to your health can be an important factor when selecting a pesticide. This factsheet is intended to help you understand how the toxicity of pesticides is determined and how you can use that information to inform your pest management decisions.

Understanding the Terms

Some terms casually used in relation to pesticides refer to broader definitions that have very specific meanings deserving precise attention. Toxicity is the degree to which a chemical substance, or a particular mixture of chemical substances, can harm an organism. EVERY chemical substance has some level of toxicity to it. Even water can be toxic when given in a large enough dose.

There are two types of toxicity that should be differentiated. Acute toxicity is the degree to which a chemical substance can cause immediate harm from exposure. An example of this is the immediate nausea that occurs when someone drinks a dose of ipecac syrup. Acute toxicity is a concern when using pesticides because accidental exposure from a spill or ingestion of some chemicals can cause immediate illness or death. By contrast, chronic toxicity is the degree to which a chemical substance can harm a person when they are exposed to small doses over a long period of time. An example of this is the effects of small amounts of lead in drinking water over many years.

The most common way that acute toxicity is measured is through experimental tests that determine the oral LD50 (lethal dose 50%). This is the amount of an ingested substance (single dose) that causes the death of 50% of a group of test subjects. The LD50 is expressed in milligrams of chemical per kilogram of body weight (mg/kg) of the test animals. This means that the LOWER the LD50, the more toxic the chemical. A chemical with an LD50 of 5 mg/kg is far more toxic than a chemical that has an LD50 of 5000 mg/kg.

The LD50 test, along with other toxicity tests, are used to determine a pesticide’s signal word. The Environmental Protection Agency (EPA) requires signal words to be printed in capital letters on the front page of pesticide labels to alert you to how acutely toxic a pesticide is to humans. Signal words include CAUTION, WARNING, and DANGER/POISON. Understanding how signal words on a pesticide label translate to acute toxicity will enable you to select a product that poses the least risk to you, yet still meets your pest management needs.

Acute Toxicity Tests

The oral LD_{50} test is the starting point for determining acute pesticide toxicity. Understanding how the LD_{50} test is conducted will help you understand how signal words are determined.

The oral LD_{50} is determined through repeated tests in which groups of rats (typically, but other animals may also be used) are fed known single doses of a pesticide. The animals are monitored, and the calculated dose that causes death in 50% of the test animals is established as the LD_{50} for that pesticide. It should be noted that the testing is conducted on the pesticide as it is intended for sale or distribution. That means that the concentrated formulation of a pesticide that you buy in the store is tested, NOT the diluted formulation that you might use on your application site.

You might ask the question, **“Why test on rats? Rats are different from humans.”** While rats certainly are different from humans, they are mammals and are biologically similar enough to be used as test subjects. Additionally, individual rats are very similar to each other in their response to toxins, and they can be mass-produced. Scientists can conduct large numbers of tests on rats and be assured that the results are reliable.

Another valid question is, **"Why use the 50% mark in a group of rats?"** While other tests are conducted to determine what causes lower or higher levels of mortality (e.g., the LD_{20} or LD_{90}), the LD_{50} test measures how the average test subject responds. Thus, the LD_{50} is the most reliable measure of how a substance could harm the average human.

A common misperception is that the EPA conducts the toxicology tests upon which a pesticide's human health risks are established. While the EPA does employ scientists to confirm many tests, it is the pesticide manufacturers who must conduct the massive number of required experiments to determine if a pesticide is safe when used as the label directs. The EPA sets stringent guidelines about which tests must be performed and how the manufacturers must conduct them. More information about the many tests the EPA requires can be found here: [epa.gov/test-guidelines-pesticides-and-toxic-substances.](epa.gov/test-guidelines-pesticides-and-toxic-substances)

The EPA requires additional acute toxicity tests, based on the different routes of exposure to a pesticide, to determine which signal word must be displayed on the label. These include the dermal LD_{50} test, (determines the effects of skin exposure), the inhalation LC_{50} test (lethal concentration 50%; determines the harm caused by breathing a pesticide), and other toxicity tests to determine skin and eye irritation caused by a pesticide.

Determining Signal Words

The EPA uses verified results from the various toxicity tests to assign a pesticide to one of four categories. Each category reflects the highest risk to human health posed by the different exposure routes. This means that a pesticide that presents only a moderate risk via ingestion, but a very high risk from skin exposure, would be classified based on the dermal risk. Table 1 (at the end of this factsheet) displays the pesticide toxicity categories along with the associated label signal words.

Understanding the Dose Measurements

The toxicity data presented in Table 1 are measured in mg/kg. This information is often difficult to picture. Do you know how much a milligram is? Do you know your weight in kilograms? Most people don't. Therefore, it is useful to have a shorthand method for picturing the amount of pesticide concentrate that is capable of making you ill or causing death. Table 2 presents the oral LD_{50} and the size of an oral dose that would likely prove fatal to an "average adult" weighing approximately 180 pounds. It should be understood that children can be much more vulnerable to pesticide poisonings because of their smaller size and weight, and their different biological susceptibility.

Table 2. Toxicity measures and lethal doses.

Oral LD_{50} (mg of toxin/kg of body weight)	**Lethal Dose (for "average adult")**
0 - 5	a drop or a pinch
5 - 50	a few drops to one teaspoon
50 - 500	1 teaspoon to 1 tablespoon
500 – 5,000	1 ounce to 1 pint
> 5,000	> 1 pint

Looking again at Table 1, you can see why a pesticide with an oral LD_{50} of less than 10 mg/kg (e.g., parathion) would be required to have a **DANGER/POISON** signal word designation on the label. You could ingest a lethal dose of this pesticide if it accidentally splashed into your mouth during mixing or loading. This is also why a pesticide with a **DANGER/POISON** signal word has much stricter personal protective equipment (PPE) requirements on the label. By contrast, a pesticide with an oral

LD_{50} of greater than 5,000 mg/kg (e.g., neem) would receive a signal word of **CAUTION**. A pesticide at this level would require more than a pint to be ingested to cause illness or death. It is very unlikely that someone would accidentally consume that volume of pesticide.

Remember, every chemical substance has some level of toxicity. The size of the dose is what determines how much it can harm you. Even common foods, drinks, and medications can cause illness (or even death) if consumed in large enough doses. Table 3 displays a few of these common items with their associated oral LD_{50}.

Table 3. Toxicity of common chemical substances.

Substance	**Oral LD_{50} (mg of toxin/kg of body weight)**
Nicotine	50
Caffeine	192
Ibuprofen	636
Salt (sodium chloride)	3000
Sugar	29,700

People intentionally expose themselves to small doses of chemical substances to create a desired effect. This may be to flavor their food, alleviate a headache, or to get a boost of energy. Regardless, in sufficient doses, all chemical substances can be lethal. Always remember, “the dose makes the poison.”

Chronic Toxicity Tests

Along with acute toxicity testing, the EPA requires pesticide manufacturers to conduct long-term studies to determine the effects of exposure to small, non-lethal doses of pesticides. These tests are conducted on a variety of animals to determine if a pesticide can be safely used to control a target pest.

If the EPA determines that small exposures to a pesticide over the course of a human lifetime would cause a significant increase in the likelihood of harm (e.g., cancer, birth defects, tumor generation), then they place further restrictions on how a pesticide can be used. In many cases, the EPA opts to deny registration of a pesticide if the risks to human health are too great.

Selecting an Appropriate Pesticide

When managing pest problems, you should always explore the cultural, mechanical, and biological control options available to you before resorting to a pesticide solution. In the event that pesticides are warranted, always choose a product that will solve your problem, yet pose the fewest risks to your health, non-target species, and the environment. This publication should help you better understand the toxicity risks associated with the different pesticides you might choose.

Table 1. EPA acute toxicity categories and signal words based on toxicity data.

	High Toxicity (DANGER/DANGER-POISON) Category I	**Moderate Toxicity (WARNING) Category II**	**Low Toxicity (CAUTION) Category III**	**Very Low Toxicity (Optional Signal Word: CAUTION) Category IV**
Oral LD_{50}	Up to and including 50 mg/kg (≤50 mg/kg)	Greater than 50 through 500 mg/kg (>50 – 500 mg/kg)	Greater than 500 through 5000 mg/kg (>500 – 5000 mg/kg)	Greater than 5000 mg/kg (>5000 mg/kg)
Inhalation LC_{50}	Up to and including 0.05 mg/L (≤0.05 mg/L)	Greater than 0.05 through 0.5 mg/L (>0.05 – 0.5 mg/L)	Greater than 0.5 through 2.0 mg/L (>0.5 – 2.0 mg/L)	Greater than 2.0 mg/L (>2.0 mg/L)
Dermal LD_{50}	Up to and including 200 mg/kg (≤200 mg/kg)	Greater than 200 through 2000 mg/kg (>200 – 2000 mg/kg)	Greater than 2000 through 5000 mg/kg (>2000 – 5000 mg/kg)	Greater than 5000 mg/kg (>5000 mg/kg)
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or other eye irritation clearing in 8 – 21 days	Corneal involvement or other eye irritation clearing in 7 days or less	Minimal effect clearing in less than 24 hours
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema or edema)	Mild or slight irritation at 72 hours (no irritation or erythema)

Source: U.S. Environmental Protection Agency, 40 C.F.R. § 156.62 (2011).

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