Soil Quality Information Sheet

Soil Quality Concerns: Pesticides

USDA Natural Resouces Conservation Service January 1998

What are pesticides?

Pesticides are synthetic organic chemicals used to control weeds in fields and lawns, and unwanted or harmful pests, such as insects and mites that feed on crops. Pesticides are divided into categories according to the target organisms they are designed to control (e.g., insecticides control insects).

Herbicides are by far the most commonly used pesticides in the United States. They range from non selective to highly selective for control of specific weeds in specific crops, with different products having postemergence, preplant, and preemergence uses. Insecticides are second in usage, and fungicides are third.

Effects of Pesticides on Soil Quality

The capacity of the soil to filter, buffer, degrade, immobilize, and detoxify pesticides is a function or quality of the soil. Soil quality also encompasses the impacts that soil use and management can have on water and air quality, and on human and animal health. The presence and bio-availability of pesticides in soil can adversely impact human and animal health, and beneficial plants and soil organisms. Pesticides can move off-site contaminating surface and groundwater and possibly causing adverse impacts on aquatic ecosystems.

What are pesticide formulations?

The formulation is the chemical and physical form in which the pesticide is sold for use. The active ingredient (a.i.) is the chemical in the formulation that has the specific effect on the target organism. The formulation improves the properties of the pesticides for storage, handling, application, effectiveness, or safety. Examples of formulated products are wettable powders and water-dispersible granules. A single pesticide is often sold in several different formulations, depending on use requirements and application needs.

Pesticide mode of action

Mode of action refers to the mechanism by which the pesticide kills or interacts with the target organism.

- Contact pesticides kill the target organism by weakening or disrupting the cellular membranes; death can be very rapid.
- Systemic pesticides must be absorbed or ingested by the target organism to disrupt its physiological or metabolic processes; generally they are slow acting.

How effective the pesticides are at killing the target organisms (efficacy) depends on the properties of the pesticide and the soil, formulation, application technique, agricultural management, characteristics of the crop, environmental or weather conditions, and the nature and behavior of the target organism.

Fate of pesticides in the environment

Ideally, a pesticide stays in the treated area long enough to produce the desired effect and then degrades into harmless materials. Three primary modes of degradation occur in soils:

- biological - breakdown by micro-organisms
- chemical - breakdown by chemical reactions, such as hydrolysis and redox reactions
- photochemical - breakdown by ultraviolet or visible light

The rate at which a chemical degrades is expressed as the half-life. The half-life is the amount of time it takes for half of the pesticide to be converted into something else, or its concentration is half of its initial level. The half-life of a pesticide depends on soil type, its formulation, and environmental conditions (e.g., temperature, moisture). Other processes that influence the fate of the chemical include plant uptake, soil sorption, leaching, and volatilization. If pesticides move off-site (e.g., wind drift, runoff, leaching), they are considered to be pollutants. The potential for pesticides to move off-site depends on the chemical properties and formulation of the pesticide, soil properties, rate and method of application, pesticide persistence, frequency and timing of rainfall or irrigation, and depth to ground water.

Retention of pesticides in the soil

Retention refers to the ability of the soil to hold a pesticide in place and not allow it to be transported. Adsorption is the primary process of how the soil retains a pesticide and is defined as the accumulation of a pesticide on the soil particle surfaces. Pesticide adsorption to soil depends on both the chemical properties of the pesticide (i.e., water solubility, polarity) and properties of the soil (i.e., organic matter and clay contents, pH, surface charge characteristics, permeability). For most pesticides, organic matter is the most important soil property controlling the degree of adsorption.

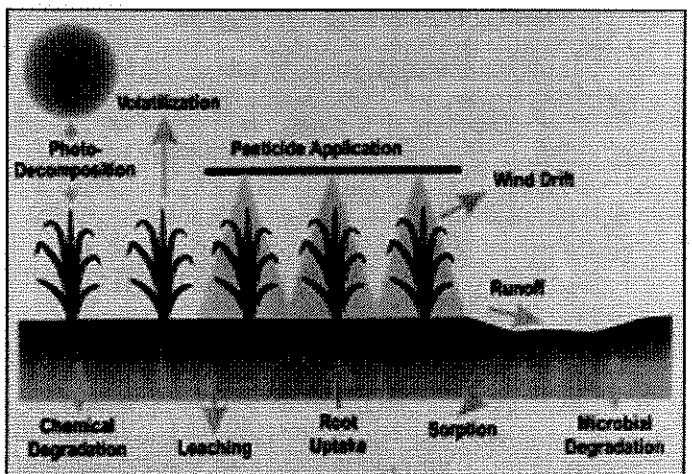
For most pesticides, the degree of adsorption is described by an adsorption distribution coefficient (K_d), which is mathematically defined as the amount of pesticide in soil solution divided by the amount adsorbed to the soil.

(Prepared by the National Soil Survey Center in cooperation with the Soil Quality Institute, NRCS, USDA, and the National Soil Tilth Laboratory, Agricultural Research Service, USDA).

Pesticide toxicity

The toxicity level of a pesticide depends on the deadliness of the chemical, the dose, the length of exposure, and the route of entry or absorption by the body. Pesticide degradation in soil generally results in a reduction in toxicity; however, some pesticides have breakdown products (metabolites) that are more toxic than the parent compound.

Pesticides are classified according to their potential toxicity to humans and other animals and organisms, as restricted-use (can only be purchased and applied by certified persons who have had training in pesticide application), and general use (may be purchased and applied by any person).



Fate of pesticides in the environment (after Aislabie and Lloyd-Jones).

Use and application considerations

- Apply pesticides at the lowest effective level.
- Avoid unnecessary pesticide treatments.
- Use Integrated Pest Management.
- Follow all label instructions.
- Apply proper rates and times as label indicates.
- Calibrate application equipment.
- Apply formulations that minimize drift.
- Use safety equipment when handling.
- Store and dispose of pesticide containers properly.
- Use biological controls when appropriate.
- Alter farming or cropping systems to control pests.
- Use disease and insect resistant crop varieties.

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