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# G93-1182 Best Management Practices for Agricultural Pesticides to Protect Water Resources

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# Best Management Practices for Agricultural Pesticides to Protect Water Resources

**This NebGuide discusses what happens to pesticides after application, factors affecting pesticide movement, and best management practices to minimize the potential for pesticide contamination of ground and surface water.**

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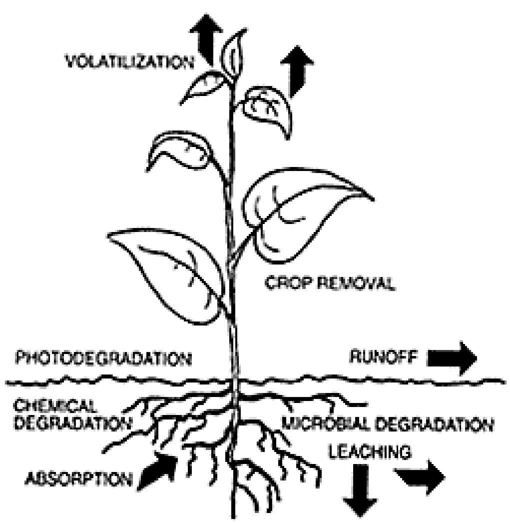


Users of pesticides and other agricultural chemicals must take appropriate precautions to reduce the risks of moving these materials into ground or surface water. The primary consideration should be whether the chemical is needed. If pesticides are needed, then the characteristics of the chemical, the sensitivity of the application site and the method of application should be considered.

**Figure 1. The fate processes of pesticides.**

The simplest way to minimize the potential for pesticide movement into water is to reduce or eliminate pesticide use. This can be accomplished by substituting nonchemical control measures for pesticides, where possible, and by using recommended **Best Management Practices** to minimize pest populations and reduce the need to use pesticides, thus protecting water resources. If pesticides are to be used, proper handling and application according to label instructions is essential. Select an effective pesticide for the intended use and, where possible, use those with lower human and environmental risk.

## Factors affecting pesticide fate after application

It is important to understand what happens to pesticides after they are applied in the field. Not all of the applied chemical reaches the target site, some may **drift** downwind and outside the intended application site, possibly to nontarget sites, including surface water. pesticides should **only** be applied when drift potential is low (see NebGuide *G90-1001*, *Spray Drift of pesticides*). Of the pesticide remaining at the application site, three major processes determine its fate: adsorption, transfer and degradation (see *Figure 1*).

**Adsorption** is the chemical process that results in a pesticide being bound or adsorbed to a soil particle. For example, portions of a pesticide molecule may bind electrically to clay minerals or organic matter.

**Transfer** refers to processes that move the pesticide away from the application site and includes *volatilization, runoff, leaching, absorption* and *crop removal*. Sometimes pesticide transfer is essential for pest control. For example, certain preemergence herbicides must move within the soil to reach germinating weed seeds. Volatilization occurs when a liquid or solid converts to a gas and moves away from the initial application site. Runoff occurs when water is added to a field faster than it can be absorbed into the soil. pesticides may move with runoff as compounds dissolved in the water or attached to soil particles. Leaching is the downward movement of chemical through the soil, eventually reaching the groundwater. Absorption is the uptake of pesticides or other chemicals into the plant or animal. After absorption, the pesticide residue may be broken down or remain in the plant or animal until harvest. Crop removal through harvest or grazing may move pesticide residue.

**Degradation** is the process of pesticide breakdown after application by either microbial action, chemical action or photodegradation. This process may take hours, days, weeks or years, depending on environmental conditions and the chemical characteristics of the pesticide.

The factors influencing whether pesticides will be leached into groundwater include characteristics of the soil and the pesticide, and their interaction with water from irrigation or rainfall. These factors are summarized in *Table I*. Similar factors influence pesticide movement in surface runoff, except that pesticides with low water solubility may move with surface runoff if they are strongly adsorbed to soil particles and have some degree of persistence. As shown in *Table I,* soil characteristics are important to pesticide movement. For example, clay soils have a high capacity to adsorb many chemicals including pesticides and soil nutrients. Sandy soils have a much lower capacity to adsorb pesticides. Organic matter in the soil also can adsorb pesticides. Soil structure influences the movement of water and pesticides. Coarse textured sandy soils with large macropores allow more rapid movement of water than fine textured or compacted soils with fewer macropores. Other characteristics of the site, such as depth to groundwater, or distance to surface water, are important. Finally, the pattern of water falling on the soil through irrigation or rainfall is significant. Small volumes of water at infrequent intervals are less likely to move pesticides than large volumes of water at more frequent intervals.

**Table I. Summary of groundwater contamination potential as influenced by water, pesticide and soil characteristics.**

| | **Risk of groundwater contamination** | |
|---|---|---|
| | **Low risk** | **High risk** |
| **pesticide characteristics** | | |
| Water solubility | low | high |
| Soil adsorption | high | low |
| Persistence | low | high |

| | | |
|---|---|---|
| **Soil characteristics** | | |
| Texture | fine clay | coarse sand |
| Organic matter | high | low |
| Macropores | few, small | many, large |
| Depth to groundwater | deep<br>(100 ft or more) | shallow<br>(20 ft or less) |
| **Water volume** | | |
| Rain/irrigation | small volumes at<br>infrequent intervals | large volumes at<br>frequent intervals |
| Based on: McBride, D. K. 1989. Managing pesticides to prevent groundwater contamination. North Dakota State University Extension Service, Publication E-979. | | |

pesticide characteristics (see *Table I*) are also important and include solubility in water, tendency to adsorb to the soil, and persistence in the environment (or half-life). pesticides with high water solubility, low tendency to adsorb to soil particles and long persistence or half-life have the highest potential to move into water. These three factors, **soil adsorption, water solubility** and **persistence**, are commonly used to rate pesticides for their potential to leach or move with surface runoff after application. Soil adsorption is measured by $K_{oc}$, which is the tendency of pesticides to be attached to soil particles. Higher values (greater than 1000) indicate a pesticide that is very strongly attached to soil and is less likely to move unless soil erosion occurs. Lower values (less than 300-500) indicate pesticides that tend to move with water and have the potential to leach or move with surface runoff.

Solubility is measured in parts per million (ppm) and measures how easily a pesticide may be washed off the crop, leach into the soil or move with surface runoff. pesticides with solubilities of less than 1 ppm tend to remain on the soil surface. They tend not to be leached, but may move with soil sediment in surface runoff if soil erosion occurs. pesticides with solubilities greater than 30 ppm are more likely to move with water.

pesticide persistence is measured in terms of the half-life, or the time in days required for a pesticide to degrade in soil to one-half its original amount. For example, if a pesticide has a half-life of 15 days, 50 percent of the pesticide applied will still be present 15 days after application and half of that amount (25 percent of the original) will be present after 30 days. In general, the longer the half-life, the greater the potential for pesticide movement. A pesticide with a half-life greater than 21 days may persist long enough to leach or move with surface runoff before it degrades.

No one factor--adsorption, water solubility, or persistence--can be used to predict pesticide behavior. It is the interaction of these factors and their interaction with the particular soil type and environmental conditions that determines pesticide behavior in the field.

## Risk estimates for pesticide contamination of water

An example of rating the risk of some common pesticides according to the three factors, adsorption, water solubility and persistence, is shown in *Table II*. More detailed information on these and additional pesticides is available at your local Soil Conservation Service (SCS) office. SCS maintains a pesticide database and a field soil series database which characterizes each as to its potential for loss from leaching or surface runoff. They have developed a procedure to combine the pesticide rating and the soil type rating to compute an overall rating of the potential of a particular field to have pesticide movement

by leaching or surface runoff. *Caution*: The values in *Table II* are **approximations** and may vary depending on environmental factors at an individual site. The ratings for movement by leaching or surface runoff do provide **relative risk estimates** however, and are useful for comparisons between products.

**Table II. Physical properties of some commonly used pesticides and ratings for potential of off-site movement through surface water runoff or leaching.**

| pesticide Common name (Brand name) | Soil Sorption Index[a] | Water Solubility[b] | Soil Half-life[c] | Rating for movement by | |
|---|---|---|---|---|---|
| | | | | Surface Runoff | Leaching |
| | ($K_{oc}$) | (ppm) | (days) | | |
| alachlor (Lasso) | 170 | 240 | 15 | Medium | Medium |
| atrazine (Aatrex) | 100 | 33 | 60 | Medium | Large |
| carbaryl (Sevin) | 200 | 114 | 10 | Medium | Small |
| carbofuran (Furadan) | 22 | 351 | 50 | Small | Large |
| chlorpyrifos (Lorsban) | 6,070 | 2 | 30 | Large | Small |
| fonofos (Dyfonate) | 532 | 13 | 45 | Large | Medium |
| methyl parathion (Penncap-M) | 5,100 | 60 | 5 | Medium | Small |
| metolachlor (Dual) | 200 | 530 | 20 | Medium | Medium |
| permethrin (Ambush, Pounce) | 86,600 | 0.2 | 32 | Large | Small |
| terbufos (Counter) | 3,000 | 5 | 5 | Medium | Small |

Source: R. L. Becker et al. (1989) Minnesota Extension Service AG-BU-3911.
[a]Values greater than 1000 indicate a pesticide is strongly attached to the soil.
[b]Values of 1 ppm or less are low in solubility and tend not to leach.
[c]Values greater than 21 days may persist in the soil long enough to leach or move with surface water.

When pesticides need to be used, selections should be influenced by the specific characteristics of each field. Consider the potential for leaching or surface water runoff, and avoid using pesticides with high potential for leaching or runoff on sensitive sites.

## Best Management Practices to protect water resources

Best Management Practices (BMPs) in the context of this discussion, are defined as practices which reduce the potential for pesticides moving into water either by surface runoff or by leaching into

groundwater. Although not an inclusive list, the following BMPs are suggested for incorporation into all farming and ranching operations:

- **Integrated Pest Management**

  Integrated pest management (IPM) is the use of all means of pest control (chemical and nonchemical) in a compatible fashion to reduce crop losses. pesticides are the last line of defense and are used only when pest levels are causing sufficient damage to offset the expense of the application. IPM also requires the following actions:

  Regular **field scouting** or monitoring to check levels of pest populations and their damage to determine management needs, be it a pesticide application or other management actions. Scouting can be accomplished by a trained family member, or for example, by hiring a crop consultant. Educational materials and training are available through the Field Crops IPM Program at UNL. **Nonchemical control measures** are highly recommended. These include mechanical, cultural and biological controls, sanitation and plant resistance. Where possible, for example, use crop rotation to manage corn rootworms and cut alfalfa early to manage weevils (cultural controls); select resistant varieties (plant resistance); thoroughly clean combines between fields to reduce weed seed introductions (sanitation); and use cultivation to control weeds (mechanical control).

  Maximize the benefits of naturally occurring **biological controls** by using pesticides only when necessary. Most insecticides are broad spectrum materials and affect beneficial insects and other arthropods as well as pests. For example, spider mite outbreaks late in the season may have been encouraged by an earlier insecticide application for control of another pest.

- **Prevent backsiphoning and spills**

  Never allow a hose used for filling a spray tank to extend below the level of the water in the tank. It is better to haul water to the field to fill the spray tank. It is also recommended that you mix and dilute pesticides in the field. If a pesticide spill happens, contain the spill as quickly as possible and handle according to label directions. Use anti-siphon devices in the water line. They are inexpensive and effective.

- **Consider weather and irrigation plans**

  Never start an application if a significant weather event such as rainfall is forecast and might cause drift or soil runoff at the application site. Application just before rainfall or irrigation may result in reduced efficacy if the pesticide is washed off the target crop, resulting in the need to reapply the pesticide.

- **pesticide use and storage**

  Use pesticides only when economic thresholds are reached and buy only what you need. Only store pesticides on the farm for a short time and in a locked weather-tight enclosure downstream and a reasonable distance (greater than 100 ft) from a well or any surface water. Use appropriate protective equipment and clothing according to label instructions.

- **Dispose of pesticide and chemical wastes safely**

  Use pesticides and other agricultural chemicals only when necessary. Carry water in a nurse tank

to the field to mix and measure on site. Prepare only as much as is needed. Dispose of excess chemical and its container in accordance with label directions.

- **Leave buffer zones around sensitive areas**

  Read the pesticide label for guidance on required buffer zones around water, buildings, wetlands, wildlife habitats and other sensitive areas where applications are prohibited.

- **Reduce off-target drift**

  Never begin an application when wind or temperature favors pesticide drift to an off target area. Use appropriate spray pressure and nozzle selection to minimize drift.

- **Application equipment**

  Maintain all application equipment in good working order and calibrate it regularly.

## Summary

For environmental stewardship, adopt pesticide best management practices. The following practices will reduce the potential for pesticide contamination of groundwater and surface water:

- Practice Integrated Pest Management (IPM).
- Select pesticides that are labeled for the intended application site.
- Consider application site characteristics (soil texture, slope, organic matter).
- Consider location and conditions of wells.
- Measure accurately.
- Maintain application equipment and calibrate accurately.
- Mix and load carefully.
- Prevent backsiphoning and spills.
- Use protective equipment and clothing.
- Consider impact of weather and irrigation.
- Store pesticides safely and securely.
- Dispose of wastes safely.
- Leave buffer zones around sensitive areas.
- Reduce off-target drift.

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