

Module

4

Environmental Safety

After you have completed this module, you will be able to:

- *Address concerns of potential stakeholders*
- *Outline what happens to pesticides in the environment*
- *Describe the principal environmental hazards*
- *Deal appropriately with a pesticide spill*
- *Take measures to protect non-target organisms.*

Stakeholders

Pesticides are designed to kill pests, but they also can have negative effects on other organisms or the environment. Although pesticides are carefully studied before registration is granted, they do have the potential to cause unintended damage. There is always an element of risk when pesticides are used. The risk varies with the particular circumstances and is subject to interpretation; however, it usually involves more than one person or entity.

Stakeholders may include neighbors, employees, bystanders, beekeepers, people involved in outdoor activities, municipalities and other levels of government. When you are using pesticides, consider who may be affected by the application, especially if something goes wrong, and take steps to mitigate problems. Inform your neighbors of your intent to use a pesticide, and discuss with them measures to prevent any potential adverse effects.

Precautions to protect the environment and stakeholders are related to the degree of risk to the environment and largely defined by the following four factors:

- Toxicity to non-target organisms
- Volume used
- Persistence
- Mobility in the environment.

The greater any of these factors, the higher the risk. Follow the instructions on the label to minimize unintended effects. It is up to you to evaluate the impact of the intended application and to ensure that the product is used safely.

Anticipate concerns and address them to the best of your ability.

Fate of Pesticides

Pesticide fate is what happens to a pesticide once it is released into the environment and is largely determined by the following properties:

- Degradation-the breakdown of a product into component parts
- Adsorption-the binding of chemicals to the surface of materials
- Absorption-the movement of pesticides into organisms or materials
- Volatility-the ability of pesticides to change to the gaseous phase (from liquid or solid)

Degradation

Degradation is the breakdown of pesticides into other compounds. Pesticides are broken down by organisms, chemical reactions and sunlight. The rate of breakdown is expressed as the half-life, that is, the time required to break down 50 percent of the amount of pesticide present. The longer a pesticide takes to break down, the longer the half-life.

Half-life of Various Pesticides



- 172-439 Days for metribuzin (Sencor™)
- 10-46 days for triclopyr (Remedy™)
- 145-554 days for triticonazole (Charter™)
- 2-14 days for methomyl (Lannate™)

Breakdown By Organisms

Breakdown by organisms, such as microbes, is most rapid when:

- Temperatures are above 20°
- Soil pH is between 5.5 - 7.5
- Soil fertility is good.

The half-life of pesticide is the time required to break down 50 percent of the amount of pesticide present.

Chemical Breakdown

Chemical breakdown occurs when pesticides undergo chemical reactions that are not mediated by any organism. The rate and type of such reactions is influenced by:

- Temperatures
- pH
- Moisture
- Presence of reactive compounds.

Chemical Breakdown

Organophosphate insecticides tend to break down more rapidly in alkaline soils or in water with a high pH level.

Photodegradation



Photodegradation is the breakdown of pesticides by sunlight, especially the UV portion of the light spectrum.

Adsorption and Absorption

Pesticides may be adsorbed to the surface or absorbed into the structure of materials such as clay particles. Pesticides that are absorbed tend to remain in the materials for longer without breaking down. Materials contaminated in this way may travel (e.g., clay sediments) and retain the pesticide for a long time. Pesticides that are adsorbed to surfaces are released more easily

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and may readily contaminate water, organisms that come in contact, or other materials.

The degree of adsorption or absorption determines to a large extent the movement of a pesticide in the environment. Products that are neither adsorbed nor absorbed tend to move with water, either in the form of surface runoff or water leaching through the soil profile. Products that are adsorbed or absorbed stay with the materials to which they are attached. They can still move, but this is generally linked to soil erosion.

The extent to which adsorption and absorption take place depends on the chemical properties of the pesticide and on the properties of the material it comes in contact with.

Extent of Adsorption and Absorption



Sandy soils have a much lower tendency to absorb or adsorb pesticide molecules than clay soils. Consequently pesticides applied to sandy soils tend to be more mobile, and are more subject to leaching, which can lead to contamination of groundwater and aquifers.

Volatility

Pesticides that tend to vaporize behave like gases. In the environment this means they are present in the atmosphere where they can move considerable distances.



Volatility

Research has shown that 2,4-D and several other pesticides are commonly present in rain water, sometimes at concentrations that may damage sensitive crops.

Environmental Hazards

Pesticide use can result in soil and water pollution. Pollution is described as either point source pollution or non-point source pollution.

- Point source pollution means accidental spills, deliberate actions or discharges from an identifiable source. These are easily cleaned up and usually non-recurring.
- Non-point source pollution refers to pollution from the normal use pattern. Small amounts of pollutants are widely dispersed in air, soil or water. Correcting non-point source pollution requires changes in the use pattern or banning the pollutant. It is often rather difficult to identify the specific source of the pollutant.

Soil Pollution

Pesticides are sometimes applied to soils to control pests for an extended period of time. Soils treated with persistent pesticides have limitations on their use.

Residual pesticides provide longer control, can be applied at more convenient times and may reduce the total number of treatments. These factors may reduce spray drift, pesticide handling, and perhaps total volume of pesticide applied.

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Contaminated soil with pesticide residues in it only poses a problem when there is a change in the intended use, when erosion occurs, when the pesticide is leached out of the soil, or when it poses a health hazard to humans or animals.

Water Pollution

Surface water monitoring in Alberta has identified that most surface waters contain pesticide residues.

Example
 **Water Samples**
Of over 3000 water samples taken throughout Alberta from 1995-2003, low levels of pesticides were found in 65 percent of the samples.

Water can be contaminated by:

- Runoff
- Leaching
- Erosion of soils containing pesticides
- Direct application accidental or otherwise
- Pesticide drift.

In Alberta, where there is extensive agricultural activity, watersheds had a high frequency and concentration of pesticides in the water especially after snow melt, during the main period of pesticide application (May-July) and when there is the greatest likelihood of significant rainfall (June-July). Pesticides commonly found in streams bordering agricultural land are shown in the figure below.

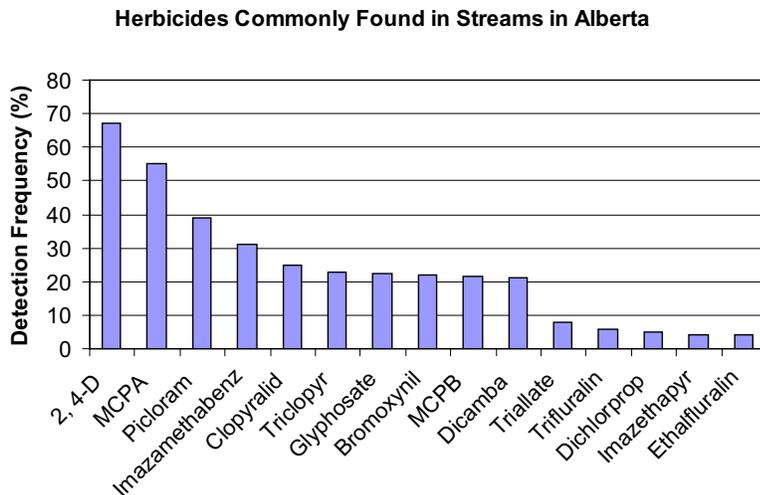


Figure 1. The graph describes the frequency (percentage of samples taken) that pesticide active ingredients are detected in samples taken from irrigation return flow water.

Once water is contaminated, any organism living in the water or using the water can be affected. These may include domestic animals, people, fish, plants, birds, wildlife, insects, etc. The water can affect them directly through contact or drinking, or indirectly through impact on the food supply or recreational activities. It is very difficult, sometimes impossible, and expensive to decontaminate groundwater and surface water.

Monitoring of water in Alberta has shown that in some cases the above guidelines have been exceeded for the following active ingredients in areas where high intensity agriculture or irrigation is being conducted:

- one sample exceeded the Drinking Water Guideline with the active, 2,4-D.
- number of samples where the Irrigation Water Guideline was exceeded:
 - i. 17 samples with the active, bromacil,
 - ii. 526 samples with the active, dicamba,
 - iii. 484 samples with the active MCPA
- samples that exceeded the Freshwater Aquatic Life Guideline:
 - i. 26 samples with 2,4-D
 - ii. 1 sample with atrazine
 - iii. 4 samples with dicamba
 - iv. 6 samples with MCPA
 - v. 4 samples with triallate
 - vi. 20 samples with chlorpyrifos
 - vii. 49 samples with lindane
 - ix. 1 sample with malathion
 - x. 1 sample with methoxychlor

If you are using any of the pesticide active ingredients identified above that have exceeded the guidelines, you should consider:

- using another pesticide active ingredient that is effective on the pest, but is not so mobile in the environment.
- providing a greater buffer zone between your application and creeks, rivers, marshes etc. that flow through your property.

Guidelines are established to determine if residues can cause an adverse effect:

- Protection of Aquatic Life Guideline—protects plants, microorganisms and fish in aquatic systems
- Drinking Water Guideline—protects humans that drink water treated for human consumption.
- Livestock Drinking Water Guideline—protects livestock that drink the water.
- Irrigation Water Guideline—protects plants and crops subject to irrigation.

Dealing with Pesticide Spills

If you spill a pesticide, you must take appropriate action. It is your responsibility to act promptly to minimize any adverse effects to human health, property and the environment.

Report a pesticide spill to Alberta Environment (1-800-222-6514) if it causes, or is likely to cause, any of the following:

- Impairment to the quality or use of air, water or land
- Injury or damage to property and animal life
- Any adverse health effects
- Impairment to public safety
- Loss of enjoyment or normal use of property
- Interference with the normal conduct of business.

Measures to Take If a Spill Occurs

Use the following checklist to ensure you take appropriate action if a spill occurs.

- Protect yourself by wearing personal protective equipment.
- Isolate the affected area and keep all unauthorized people out.
- Contain and control the spill. Check the label or Material Safety Data Sheet for details.
- Call Alberta Environment if the above conditions are met.
- If the spill is a liquid, use activated charcoal, absorptive vermiculite, pet litter or sawdust to absorb it. Prevent the spill from contaminating a well or water body.
- Sweep or shovel the material into a plastic bag and store it in a container until permanent disposal.
- Consult the Material Safety Data Sheet (or the manufacturer) to determine if further decontamination is needed, and proceed as instructed.
- Once the spill is cleaned up, check your storage area to see if other pesticides were contaminated.
- Contact Alberta Environment for information concerning disposal of spilled chemicals and contaminated materials or soil.
- Decontaminate or dispose of tools, protective clothing and equipment.

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Be prepared to respond to accidental spills by having an emergency response plan.

Emergency Response Plan

- Identify of all the hazards associated with the use of pesticides.
- Develop an action plan to handle all types of emergencies and to keep emergencies from escalating and affecting other farms, communities, the environment or surrounding land.
- Keep labels and MSDS for all pesticides being used or stored.
- Post a list of emergency response phone numbers including:
 - o Alberta Environment Response Line (1-800-222-6514)
 - o Local police, fire and ambulance
 - o Poison Centre Number (1-800-332-1414)
 - o Manufacturer phone number, found on the label and MSDS.
- Assemble personal protective equipment kit that includes:
 - o Coveralls with hood and elastic at wrist and ankles
 - o Nitrile or neoprene gloves
 - o Respirator and cartridges sealed in a re-sealable plastic bag
 - o Chemical resistant rubber boots.
- Assemble a spill clean-up kit inside a container that is large enough to hold the spilled and absorbed pesticide and include:
 - o Broom and shovel
 - o Heavy duty detergent
 - o Suitable absorbent material (see the MSDS)
 - o Suitable neutralizing material (see the MSDS)
 - o Labels and waterproof markers to label the container that will hold the spilled and absorbed material
 - o Absorbent mats or snakes to prevent spilled material from spreading from the spill site.

Report a pesticide spill to Alberta Environment (1-800-222-6514).

Protecting the Environment

In most cases the application of a pesticide results in the death of at least some organisms other than the “target” pest. For example, a certain amount of “non-target” damage is inevitable, but every pesticide user should try to minimize this damage. Livestock, pets, ornamental and crop plants are not the only non-targets of concern. Wildlife are valued and many species, unknown to the farmer, help to keep pests in check. These beneficial organisms may be unknowingly destroyed along with the pest.

Even low doses of pesticide can affect the behavior of birds, insects or other animals and make them sick, sluggish or disoriented. As a result, they are weakened and vulnerable to predation, starvation or illness, or they may abandon nests or young. These indirect effects are just as harmful to survival as fatal poisonings.

Secondary poisoning of non-target species occurs when an animal eats a poisoned pest and is itself poisoned. An example would be a coyote or a hawk dying after consuming ground squirrels poisoned with strychnine.

Protecting Fish and Aquatic Life

Most pesticides impact fish and other aquatic life, if they are allowed to enter into a water body. Pesticides that contaminate water may have a direct or indirect effect on aquatic organisms, which in turn impacts other organisms in the food chain and surrounding environment.

Most aquatic organisms are highly sensitive to pesticides in comparison to other species.

Effect of Decis® on Aquatic Life

Decis®, a synthetic pyrethroid insecticide, is not very toxic to warm blooded animals but is highly toxic to fish and aquatic insects. This in turn affects other organisms in the food chain. Ducklings, for example, can be indirectly affected by a pesticide like Decis®, if their main food source, aquatic insects, is diminished.

Pesticides can also directly affect fish and other aquatic organisms by interfering with their reproductive capabilities.

Protect fish and aquatic life by preventing pesticide contamination of water and destruction of their food or aquatic habitat. When you apply pesticides close to riparian areas, take the following special precautions.

Maintain a Buffer Zone

Buffer zones consist of natural vegetation along riparian areas that are left untreated to reduce the chance of pesticides entering streams and lakes. For buffer zones to be effective, they have to provide sufficient distance between the area treated and the body of surface water to be protected. On land that is not cultivated, the law requires that pesticides be applied no closer than 30 meters. For purposes, such as control of invasive weeds closer than 30 meters to the shoreline, a special permit is needed. This restriction doesn't apply to cultivated land, but the applicator is still responsible to insure that no pesticide is deposited directly into the water, and that precautions are taken to avoid movement of pesticides into streams, rivers, or lakes through soil erosion.

Pesticide labels may indicate a specific buffer zone and may provide options to allow a farmer to spray closer to the water body but not increase the risk of contaminating the water body. Examples of options that may be referred to on a label to help reduce buffers include:

- using a coarse nozzle
- using boom shrouds or nozzle cones
- using a wide angle nozzle that allow the boom to be lowered so it is closer to the crop and still provide a uniform application rate.

Select a Product Least Likely to Affect Aquatic Organisms

Check the label to determine toxicity to fish and other aquatic organisms. Avoid products that are highly toxic to any of these. Use products that degrade rapidly in the soil and therefore are not likely to leach or to find their way into surface water in runoff. Choose a product with good rainfastness and apply only when there is no rain in the forecast. Use low drift nozzles and don't apply in windy conditions.

Protecting Bees and Other Beneficial Insects

Poisoning of honey bees has been a significant problem in Alberta.

Steps to Prevent Honey Bee Poisoning

- Alert local beekeepers. Let them know when you plan to spray and what pesticides you'll be using. They may have to protect or move their bees.
- Do not apply pesticides near hives.
- Do not apply pesticides that are toxic to bees while crops or weeds are in bloom. Bees attracted to the flowers of treated plants may come in contact with pesticides.
- Mow cover crops and weeds to remove blooms prior to spraying.
- Select the pesticide and formulation least harmful to bees.

Least hazardous *Most hazardous* 
granules – dusts – sprays – wettable powders – soluble solutions

- Time your pesticide applications carefully. Evening is less hazardous than early morning; both are safer than mid-day application as bees are less active during these times.

Many insects besides bees are beneficial. Beneficial insects contribute to the decay of organic matter and the cycling of soil nutrients and attack other insects and mites that are pests. Only a very small percentage of the over one million known species of insects are pests. Although all the remaining non-pest species might be considered beneficial, as they play important roles in the environment, the beneficial insects and mites used in pest management are natural enemies of pest species.

Natural Enemies of Pests

A natural enemy may be:

- A predator that is an insect or mite that consumes much prey over the course of their development. Some predators, including certain syrphid flies and the common green lacewing, are predaceous only as larvae; other lacewing species, lady beetle, ground beetles and mantids are predaceous throughout their life cycle. Predators may be generalists, feeding on a wide variety of prey, or specialists, feeding on only one or a few related species. Common predators include lady beetles, rove beetles, many ground beetles, lacewings, true bugs such as *Podisus* and *Orius*, syrphid fly larvae, mantids, spiders and mites such as *Phytoseiulus* and *Amblyseius*.
- A parasitoid develops on or within a single host during the course of its development. An adult parasitoid deposits one or more eggs into or onto the body of a host insect. The larva that hatches from each egg feeds internally or externally on the tissues and body fluids of the host, consuming it slowly. Late in the development of a parasitoid, the host dies and the parasitoid pupates inside or outside of the host's body.

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The adult parasitoid later emerges from the dead host or from a cocoon nearby.

Encouraging Beneficial Insects

Conserving or encouraging beneficial insects is important because they exist naturally and help to regulate pest densities. To do this, follow these practices:

- **Recognize beneficial insects.**
Learning to distinguish between pests and beneficial insects and mites is the first step in determining whether or not control is necessary. Use insect field guides for general identification of common species.
- **Minimize insecticide applications.**
Most insecticides kill predators and parasitoids along with pests. In many instances natural enemies are more susceptible than pests to commonly used insecticides. Treat crops only when pest populations are at economic thresholds to minimize unnecessary reductions in populations of beneficial insects.
- **Use selective insecticides or use insecticides in a selective manner.**
 - Use insecticides that kill only the pest and do not affect the beneficial insects



Example

Selective Insecticide

Bacillus thuringiensis (Bt) is toxic only to caterpillars, certain mosquitos and black fly larvae.

- Use insecticides that function only as stomach poisons as these compounds do not directly harm predators or parasitoids. These compounds are toxic only when ingested along with treated foliage.
- Use insecticides that must be applied directly to the target insect or that break down quickly on treated surfaces, such as natural pyrethrins or insecticidal soaps, which kill fewer beneficial insects.
- **Maintain a margin around standing crops and crop residues.** Many natural enemies require the protection offered by vegetation to survive:
 - Areas surrounding crops supply prey, pollen and nectar, important foods for certain adult predators and parasitoids, and some degree of protection from weather. These areas may also breed the pest. Make a careful assessment of the abundance of the pest and the predators and parasitoids in these areas before you spray.
 - Consider no-till and reduced tillage cropping systems as they tend to have greater numbers of beneficial insects.
 - Some natural enemies migrate from woodlots, fencerows and other non-crop areas to cultivated fields each spring. Preserve uncultivated areas to contribute to natural biological control.

Protecting Birds

In addition to being an essential part of the ecosystem, birds help keep insect pests in check. Do the following to protect birds:

- Use the pesticide that is least toxic when you have a choice. Generally, the one least toxic to humans is also the one that is least toxic to birds.

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- Avoid the use of granular products that are toxic to birds as they become a form of poison bait as birds forage for grit.
- Where granular or treated seeds are used, ensure they are covered by soil and that leftovers are properly disposed of.

Protecting Livestock and Wildlife

Livestock and wildlife can be harmed by pesticides. Pesticide poisoning may injure animals by causing adverse effects such as weight loss, reproductive injury or death. Pesticide residues can also accumulate in tissues of the animals making them unsuitable for consumption by predators or humans.

Livestock and wildlife can be exposed to pesticides either directly or indirectly.

- Direct exposure occurs if an animal is sprayed during an application.
- Indirect exposure occurs if an animal drinks contaminated water, eats or rubs against contaminated vegetation (especially if it licks its body) or consumes contaminated food.

Consuming Contaminated Food

Allowing treated seed to be consumed by livestock or wildlife can poison them. Wildlife and pets are also especially prone to poisoning when poisoned ground squirrels are not promptly removed and disposed of from fields.

Insecticides and rodenticides are the mostly likely types of pesticides to cause injury to humans, livestock and other wildlife.

Steps to Prevent Animal Poisoning

- Be sensitive to the presence of wildlife and their young and try to avoid applications near them or their nests.
- Read and follow all label precautions regarding protecting livestock and wildlife, such as re-entry and grazing restrictions.
- Use pesticides only when necessary.
- Select the least toxic and least persistent of the registered and recommended pesticides.
- Use target specific pesticides rather than broad based pesticides.

Environmental Safety Checklist

Use the following checklist to ensure you protect the environment during pesticide use.

- I provide buffer zones for environmentally sensitive areas on my farm.
- I know the location of the nearest pesticide container site.
- I reduce spray drift.
- I talk to beekeepers near my farm about my spray program.

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- I store treated seed away from animals, humans and feed supplies.
- I follow proper procedures for cleaning containers before disposal.
- I prevent treated seed or pesticide granules from being accessible to birds.
- I protect non-target species and the food chain.
- I protect against soil and water contamination.
- I am prepared for pesticide spills.

If you can not check off the above items, review the appropriate section.

Exercises

Exercise 4.1

Mark each statement True (T) or False (F).

- a. Modern pesticides are no longer a threat to the environment.
- b. Even when used properly, pesticides can have adverse environmental impacts.
- c. Pesticides that break down rapidly present less environmental risk than those that persist over a long time period.

Exercise 4.2

Mark each statement True (T) or False (F).

- a. Modern pesticides are so specific they kill only the target pest.
- b. Destructive impacts on the environment can occur in many ways.
- c. Farmers should always keep potential impact in mind when using pesticides.

Exercise 4.3

A buffer zone is (select the correct answer):

- a. The amount of leeway you have in water pH between the ideal for spraying and what you could use if you had to.
- b. The distance your sprayer must stay away from water.
- c. The distance you should leave untreated around any sensitive areas.

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Exercise 4.4

List three environmentally sensitive areas on your farm. Do you have buffer zones?

	Buffer Zone	
	Yes	No
1. _____	<input type="checkbox"/>	<input type="checkbox"/>
2. _____	<input type="checkbox"/>	<input type="checkbox"/>
3. _____	<input type="checkbox"/>	<input type="checkbox"/>

Exercise 4.5

Mark each statement True (T) or False (F).

- a. All field-applied pesticides can be moved by runoff.
- b. Farming practices have no effect on pesticide runoff.
- c. There is no danger of pesticides moving off target if the wind is light and the land is level.
- d. A farmer could pollute his own well without ever spilling pesticide near it or into it.
- e. Pesticide pollution from leaching is greatest in sandy or gravel soils with a high water table

Exercise 4.6

Mark each statement True (T) or False (F).

- a. There is danger to the environment from nearly all pesticide applications, but a farmer can considerably reduce the danger through careful pesticide selection, by taking precautions to minimize drift, and through the use of buffer zones.
- b. Modern pesticides are designed to break down into harmless compounds and they will do so if the farmer can keep them on the target area long enough.

Exercise 4.7

Below is a list of definitions that describe the different things that can happen to a pesticide after it has been released into the environment. Match the term with its correct definition by placing the number of the definition in the space provided.

Matching Word	Definitions
<input type="checkbox"/> 1. Absorption	a. The process of solids or liquids turning into fumes
<input type="checkbox"/> 2. Volatilization	b. The breakdown of pesticides by sunlight
<input type="checkbox"/> 3. Runoff	c. The movement of particles in water through the soil
<input type="checkbox"/> 4. Leaching	d. The movement of pesticides in water (as particles or in solution) over a sloping surface
<input type="checkbox"/> 5. Microbial breakdown	e. The breakdown of pesticides by chemical reactions in the soil
<input type="checkbox"/> 6. Chemical breakdown	f. The movement of pesticides into plants and microorganisms
<input type="checkbox"/> 7. Photodegradation	g. The movement of spray droplets out of a pesticide application area by wind
<input type="checkbox"/> 8. Spray drift	h. The use of pesticides as food by microorganisms such as fungi and bacteria

Answers

Answer 4.1

False
True
True

Answer 4.2

False
True
True

Answer 4.3

c. The distance you should leave untreated around any sensitive area.

Answer 4.5

True
False
False
True
True

Exercise 4.6

True
True

Exercise 4.7

f
a
d
c
h
e
b
g