Chapter 6

ENVIRONMENT

A healthy environment provides natural resources for industries like fishing, farming, and forestry. Prosperity in the Atlantic Provinces depends on the natural environment (fishing waters, farming soils, and forests). Pesticides can contaminate or damage these environments if they move from target sites. Those using pesticides must know the effects their actions can have on the environment. They must take precautions to reduce the risk of environmental damage.

Learning Objectives

Completing this chapter will help you to:

- **Know what happens to pesticides in the environment**
- **Know how to prevent pesticide contamination of water**
- **Know how to prevent pesticide contamination on land**

Fate of Pesticides in the Environment

A number of factors decide the fate of pesticides in the environment. They also affect the impact that a pesticide will have when applied or released by accident. These factors include:

- Adsorption
- Desorption
- Absorption
- Volatilization
- Spray drift
- Runoff
- Leaching
- Degradation

Adsorption

Adsorption is the binding of chemicals to soil or some other substance. The amount that a pesticide binds to soil depends on:

- Pesticide type
- Pesticide concentration
- Moisture content
- pH
- Soil texture

Organic soils or those with a fine clay texture are most adsorptive. Pesticides that are tightly bound or adsorbed to soil are less likely to:

- Move down through the soil layers (leach)
- Break down by microorganisms in the soil

Pesticides adsorbed to soil can be moved from exposed fields into waterways by wind or water erosion. This can contaminate water, kill fish and damage fish habitat. Careful use of pesticides near water, and respect for provincial laws on setbacks (buffers) from watercourses, can help to reduce contamination of water.

Desorption

Desorption occurs when a pesticide bound or adsorbed to soil or another substance is released. For example, soil particles contaminated with a pesticide can move into a watercourse. The adsorbed pesticide may be released on contact with water. Animals and plants in the water can then take up pesticide residues. This can harm the aquatic environment.

Figure 6-1: Absorption

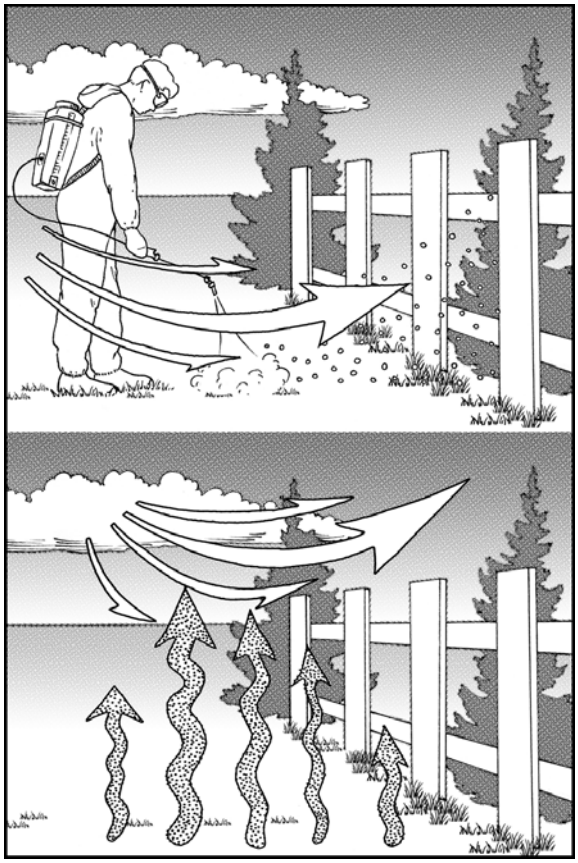
Absorption

Absorption refers to the movement of pesticides into organisms (plants or animals) or structures (soil or wood). Absorption into an organism is not always bad, since many of these organisms can break pesticides down into non-toxic compounds. In most cases, a pesticide will not be absorbed if it has adsorbed to the soil. Some pesticides need to be absorbed by an organism for the pesticide to be effective.

Volatilization

Volatilization is the process where solids or liquids become vapour (gas). The evaporation rate depends on the chemical makeup of the pesticide and environmental factors. Some pesticides can volatilize readily from sandy and wet soils. Hot, dry, windy weather also promotes volatilization. Small drops of spray

are easier to volatilize than larger ones. Pesticide vapours in the air can readily move from the application site (vapour drift). This movement is more likely to occur after, rather than during an application. Vapour drift of pesticides can contaminate nearby crops, property, or the environment.



Vapour drift can be reduced by:

- Using low spray pressures with large droplet sizes
- Not spraying when it is hot
- Following temperature application limit guidelines given by the label or provincial law
- Using low volatility formulations

Figure 6-2: In the top figure spray drift happens as a result of wind at the time of application. Vapour drift can happen after the application has been completed as in the bottom figure.

Vapour drift is the movement of vapours from the site of application. It is more likely to occur following a pesticide application.

Spray Drift

Spray drift refers to airborne movement of spray drops or particles away from a treatment site during application. Damage caused by spray drift can be similar to

that of vapour drift. However, the timing and factors that cause spray drift are different from vapour drift. Neither type of drift is good because they can:

- Damage or cause the deposit of unwanted residues on nearby crops
- Result in human or animal poisonings
- Contaminate waterways and damage aquatic organisms
- Reduce the amount of pesticide that is delivered to the target area
- Reduce pest control

Spray drift is airborne movement of spray or particles away from a treatment site <u>during</u> a pesticide application.

Spray drift is affected by:

- Size of the droplets
- Weather
- Set-up of application equipment

Spray droplet size is important in pesticide drift. Smaller droplets are more likely to drift. The factors that decrease droplet size include:

- High air temperature
- Low humidity
- Poor nozzle selection
- High application pressure

Weather also plays a role in off-target movement of pesticides. The higher the wind speed, the more likely an applied pesticide will drift. Stable air or atmospheric inversions occur when wind is calm and the air temperature at ground level is lower than that of the air above it. This can cause spray droplets to stay in the air. When the wind picks up, the droplets can then move with the air from the target. This is a factor if pesticides are to be applied using aircraft.

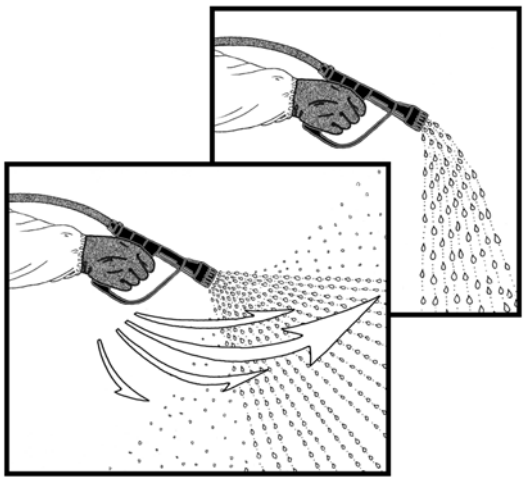


Figure 6-3: Higher pressure makes smaller droplets. These droplets are more likely to drift.

Application equipment plays a role in pesticide drift. The greater the distance between the nozzle and target, the greater the chance of drift.

To reduce spray drift, pesticide applicators should do the following:

- Avoid using high spray pressures. These can cause small droplets, depending on the type of nozzle being used.
- Avoid applying pesticides when winds are high enough to blow spray droplets from the target area. Follow wind speed guidelines on the pesticide label or as required by provincial law. Observe the lower of the two when both are present.
- Select nozzle types to produce droplet sizes that are just small enough to give good coverage.
- Decrease the distance between nozzles and the target.
- Add adjuvants to the spray tank to decrease drift.
- Consider using a granular pesticide if you need to apply pesticides in windy areas.

Runoff

Runoff refers to the movement of water down a slope. The risk of environmental contamination or damage from runoff increases if water contains pesticide residues. Pesticides can be mixed (dissolved) in water or bound (adsorbed) to soil particles that move with the water.

The amount of pesticide in runoff is affected by its formulation, concentration and solubility.

The extent of runoff depends on:

- Surface slope
- Texture and type of surface
- Adsorptive ability of the soil
- Moisture in the surface material
- Amount of added moisture (rainfall, irrigation, etc.)
- Type and amount of surface vegetation and root development

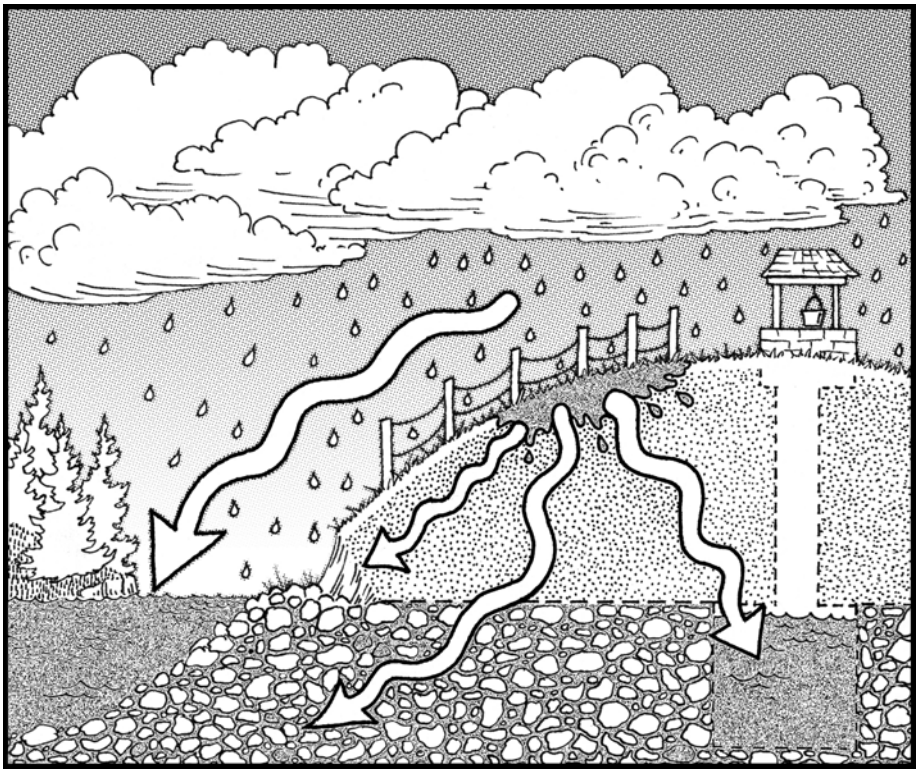


Figure 6-4: Runoff is affected by a number of factors including: slope, soil texture and rainfall.

Runoff from pesticide treated areas or areas where a pesticide spill has occurred can pollute streams, rivers, ponds and lakes. Pesticide residues in surface water can harm aquatic plants and animals, and make water unfit for human use. This can cause serious long-term damage **(See Prevention of Water Contamination)**. To reduce runoff, pesticide applicators should:

- Respect provincial laws or guidelines related to soil erosion control.
- Select adjuvants (if needed), so that the pesticide will better adhere to plants.
- Quickly incorporate the pesticide into the soil (if required).
- Respect weather conditions. If rain is expected, delay application.
- Avoid pesticide applications on highly sloped lands.

Leaching

Leaching refers to the movement of pesticides (or other chemicals) with water through the soil. Leaching can occur downward, upward, or sideways. Preservatives can leach from treated wood. Leaching is not good because it can move pesticides away from the target. This results in a waste of pesticides, poor pest control, and can contaminate or damage other sites.

Leaching occurs when:

- Pesticide solubility increases
- The soil has a low water holding capacity (gravel or sandy texture)
- Adsorption of the pesticide to soil is low or desorption is high
- Water is added (rain or irrigation)
- The soil becomes coarse

To reduce leaching and groundwater contamination:

- Use alternatives to chemical pesticides
- Use as low an application rate as the pesticide label allows
- Use a pesticide that readily adsorbs to soil and does not leach
- Do not irrigate for at least 24 hours after application
- Do not apply pesticides within 24 hours of expected precipitation

Degradation

The breakdown of pesticides into other compounds is known as degradation. Degradation of the active ingredient can occur through microbial activity, chemical activity, or photo-degradation. The rate of pesticide breakdown is referred to as its half-life. The half-life for a pesticide is determined by measuring the amount of time it takes for the initial concentration to degrade by one-half in the environment. The longer a pesticide takes to break down, the longer its half-life or persistence. Pesticides that do not readily break down are referred to as being persistent in the environment.

Pesticides can be grouped on the basis of half-life. A "typical soil half-life" value is an estimate and can vary because persistence depends on the site, soil, and climate. Pesticides that persist in the environment can pose a high risk since they have

more time to accumulate in plant or animal tissues. Sometimes, the degradation products can be more toxic than the original pesticide.

Some processes of degradation can have both good and bad effects. Generally pesticides should be less persistent in the environment; however, some pesticides can be broken down so quickly that the pest control effectiveness is greatly reduced.

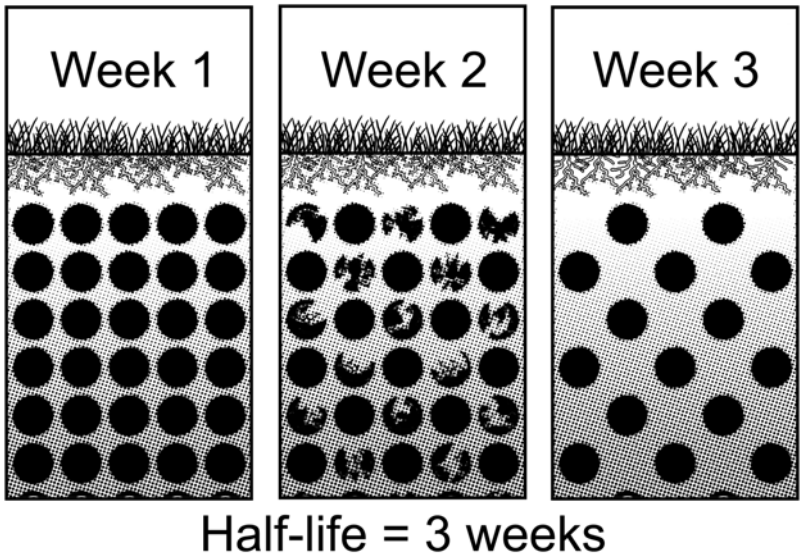


Figure 6-5: The rate of pesticide breakdown is referred to as Half-life.

Microbial Degradation

Microbial degradation is the most common form of breakdown. This refers to the use of a pesticide as an energy or food source by soil microorganisms.

Microbial breakdown is affected by:

- Temperature
- pH
- Soil moisture
- Presence or absence of oxygen
- Soil fertility
- Chemical/physical properties of the pesticide

Chemical Degradation

Chemical degradation refers to the breakdown of pesticides by chemical reactions. This occurs between the pesticide and other materials in the soil, such as water. This type of degradation usually changes the pesticide into less harmful components. The rate of chemical reaction depends on:

- Temperature
- pH
- Soil moisture
- Pesticide qualities or properties

Photodegradation

Photodegradation refers to the breakdown of pesticides by sunlight into simpler parts. Pesticides that photodegrade quickly must often be incorporated into the soil to provide effective pest control.

Contamination Sources

When an area is contaminated, the pesticide source is classed as point source or non-point source. Point source contamination occurs when a large amount of pesticide is released in a small area (e.g., accidental spill, pesticide fire, or poor disposal). Non-point source contamination occurs when a pesticide is first applied over a large area and later moves to a non-target area.

In Review

Pesticides can go through a number of processes once they have been released into the environment. When they are applied, pesticides can act in unexpected ways and greatly affect the environment. Pesticides can:

Become bound to the soil (adsorption)

- **Move from target site (runoff)**
- **Evaporate (vapour drift)**
- **Break down (degradation)**

Events like these determine whether a pesticide stays where it has been applied or causes contamination of the environment.

Aquatic Impact of Pesticides

Pesticides can contaminate both surface and groundwater. When water is contaminated, it can become toxic to humans, wildlife (on land and water), domestic animals or plants including sensitive crops.

Surface water is water that you can see, such as ditches, streams, ponds, rivers, lakes and oceans. **Ground water** is found below the surface of the earth, in zones of rock, sand, or gravel saturated with water. These zones are called **aquifers**. The **Water table** is the level below which all the space between soil particles is filled with water. The water table can vary in depth. In Atlantic Canada, much of the water used by humans and livestock comes from groundwater. Once an aquifer has been contaminated, it can remain so for a long time.

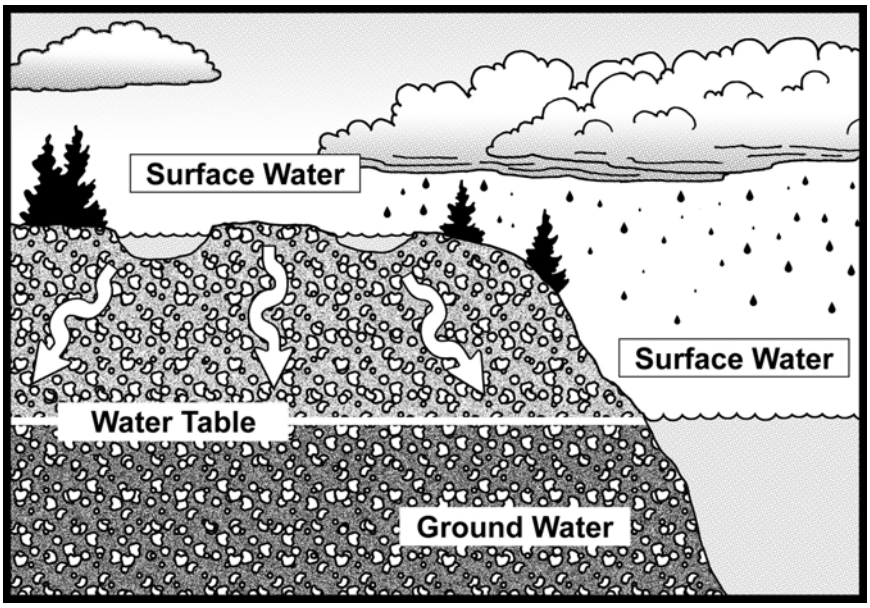


Figure 6-6: Surface water is water you can see while ground water is below the surface of the earth.

Pesticides can enter surface or groundwater due to:

- Natural processes (runoff, leaching, and erosion of soil that has adsorbed pesticides).

- Poor cleanup of spills during mixing, loading, or transporting.
- Poor disposal of excess spray mix, unwanted pesticides, or rinsate from empty containers.
- Poor handling or application of pesticides resulting in:
    - Spray drift
    - Vapour drift
    - Application rates above the label rate
- Poor handling or application of pesticides including:
    - Failure to clean up spills
    - Back-siphoning of pesticides from the spray tank to the water source
    - Overflow of the spray tank during filling
    - Careless washing of spray equipment

Prevention of Water Contamination

When surface water is contaminated, any animal or plant living in or using the water can be affected. These include humans, domestic animals, wildlife, beneficial insects, and plants. Contamination can affect them directly (by contact or drinking), or indirectly (by impacting food supplies or recreational activities). It is very expensive, sometimes impossible, to decontaminate surface or groundwater. It is best to make every effort to prevent contamination.

The best solution to water contamination is prevention.

To prevent water contamination:

- Never apply pesticides near a body of water. Leave a buffer zone (an area not treated) next to a water body. Follow label buffer statements or provincial laws regarding aquatic setbacks or buffers.

- Apply pesticides using label guidelines.
- Make sure that sprayers are calibrated and all equipment is maintained.
- Spray only in proper environmental conditions.
- Never wash application equipment close to a well, lake, river, or other water body. Wash water can contaminate.
- Prevent back siphoning of tank contents when filling spray application equipment. Tank contents can flow back through the filler hose into the water supply. This will cause direct water contamination. Prevent contamination of the original water source from backflow by:
    - Filling the sprayer away from water bodies
    - Using a nurse tank
    - Keeping the end of the filler hose above the water level in the spray tank at all times
    - Using an anti-backflow device (e.g., spring-loaded check valve) when taking water directly from a source

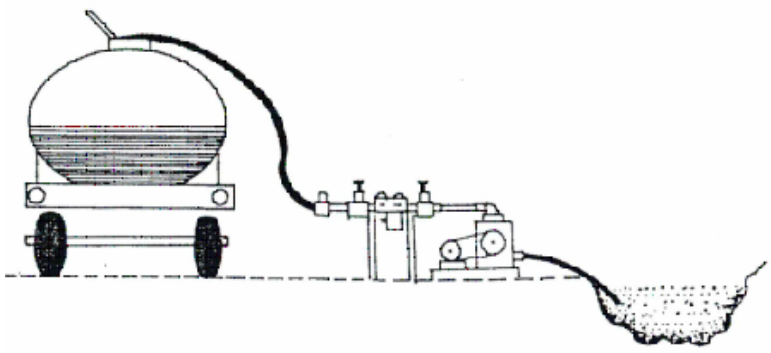


Figure 6-7: Anti backflow device

Impact of Water Contamination on Fish and Aquatic Organisms

Pesticides that contaminate water can harm the aquatic ecosystem (fish, insect larvae, and plant life). Most pesticides will harm aquatic communities. Take great care near water bodies. Check the pesticide label for warnings that the pesticide is toxic to fish.

Some pesticides are more toxic to aquatic life than they are to humans and land animals.

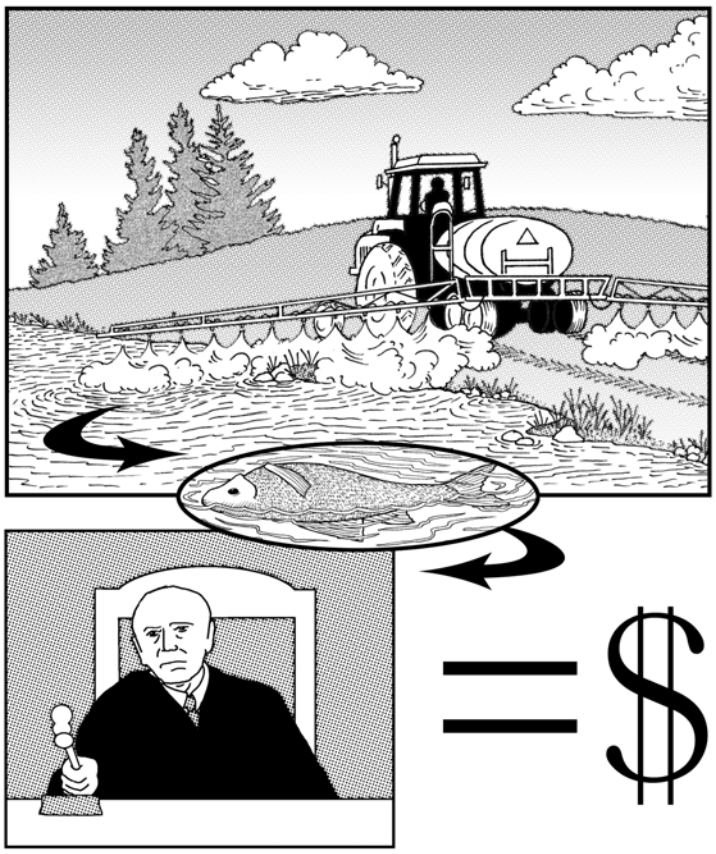


Figure 6-8: Those who damage fish or fish habitat using pesticides may be prosecuted under provincial law or the federal *Fisheries Act*.

Aquatic life can be **directly** harmed or killed if pesticides get into water. This happens through:

- Spray or vapour drift
- Runoff
- Soil erosion
- Leaching
- Improper release of pesticides (e.g., spills or over-spray)

Aquatic life can be harmed **indirectly** when low-level pesticide contamination:

- Kills food organisms
- Removes water or streamside plants
- Disrupts mating or feeding

Pesticide applicators can help prevent contamination of water and destruction of aquatic food sources by:

- Applying pesticides safely.
- Reading the label and using the correct pesticide application rate.
- Avoiding the use of pesticides that are highly toxic to fish, near water or shallow aquifers.
- Keeping buffer zones (as directed by provincial laws or label warnings) when mixing, loading, or applying pesticides.
- Showing care and restraint when using pesticides near fish habitat or areas that drain into fish habitat.
- Avoiding pesticides that:
    - Tend to leach to shallow aquifers
    - Have high runoff potential
    - Have high aquatic toxicity

Impact of Water Contamination on Other Forms of Life

Pesticide contaminated water can affect all life. It can harm humans, domestic animals, wildlife, or plants. Any animal that drinks contaminated water can be affected. Sometimes birds and mammals may not be affected, but can transfer pesticide residues to offspring. These offspring may die or suffer long-term damage.

In Review

Pesticide contamination of surface or groundwater can have a major impact on aquatic life, humans, and animals. Toxic impacts include direct effects on organisms or indirect effects on the food supply, habitat, or mating. When surface water is contaminated, it is always expensive, and often impossible, to decontaminate. The best way to reduce the chance of contamination is to prevent it. Following safety measures when transporting, loading, mixing, or applying pesticides can prevent contamination.

Terrestrial Impact of Pesticides

Pesticide use can impact many aspects of the land environment. This includes animals, beneficial insects, plants, soil and air.

Soil Contamination

There are many ways that pesticides can contaminate soil. These include:

- Spills during mixing and loading
- Overflow from application equipment
- Poor container or pesticide disposal
- Exceeding the proper application rate

Soil contamination can:

- Damage or leave residues in plants
- Harm soil bacteria and earthworms
- Contaminate drinking and irrigation water

Pesticide spills are affected by soil textures. A spill on sandy or coarse-textured soils can leach and lead to contamination of groundwater. Pesticide spilled on clay or fine-textured soils can remain on the surface. This is likely to move away over time through surface runoff.

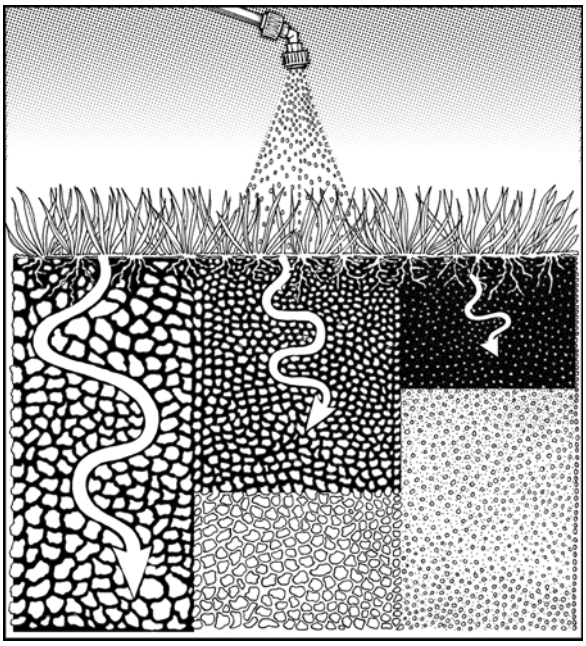


Figure 6-9: Pesticides can move through sandy soil faster than clay soil.

Reduce the chance of soil contamination by:

- Following all label directions and precautions
- Complying with federal and provincial laws
- Using care when mixing and loading (e.g., not overfilling equipment)
- Reducing pesticide drift
- Disposing of excess pesticide mixtures and empty containers
- Cleaning up all spills at once

Air Contamination

Air can be contaminated by pesticide as spray droplets, mists, dusts, or vapours. Once in the air, pesticides can move to water bodies, non-target organisms, nearby crops, or soil. This can cause direct or indirect damage. Vapours from a herbicide application can drift to a sensitive crop hundreds of metres downwind. This can leave residues or cause phytotoxic effects. Contaminated air can also concentrate in enclosed spaces (like a greenhouse) and harm applicators, crop workers, customers, or non-target organisms.

Air contamination can be reduced by using safety guidelines designed to control pesticide drift**. (See Chapter 8: Application Technology.)**

Animals (wildlife, birds, domestic animals, and other land animals)

When directly or indirectly exposed to toxic pesticides, animals can suffer:

- Adverse affects (e.g., weight loss, reproductive failure)
- Long-term damage
- Death

Animals can be harmed **directly** by exposure during application (contact or inhalation). They can suffer **indirectly** by contacting contaminated:

- Water
- Vegetation (e.g., brushing against it)
- Soil
- Food (e.g., treated seed, poisoned animals, or contaminated vegetation)

Animal and bird populations can be harmed through:

- Destruction of wildlife habitat
- Contamination of nests, dens, or burrows
- Destruction of food supply

Pesticides in animal tissues can make them unfit for humans to eat. Because of their generally higher toxicity to mammals, insecticides and rodenticides tend to be more poisonous to wildlife than other forms of pesticides.

Pesticide applicators can help protect animals from ill effects of pesticide exposure by:

- Respecting wildlife
- Reading and following all pesticide label information
- Following safety guidelines described in this manual
- Using pesticides only when needed
- Selecting less toxic and less persistent pesticides
- Using target-specific pesticides to reduce the impact on other organisms
- Knowing the effects that granular pesticides and treated seed can have on wildlife
- Ensuring that pesticides are properly used and stored
- Removing poisoned rodents in a proper manner (These can cause secondary poisonings of pets or other animals.)
- Avoiding pesticides that are likely to move away from the area of application through drift or runoff
- Leaving buffer zones around sensitive areas

Beneficial Insects

Pollinators (bees), insect predators, and decomposers are beneficial insects. People need them to perform many useful functions such as:

- Pollinating fruit trees
- Controlling nuisance insects (e.g., aphids)
- Breaking down waste vegetation

Beneficial insects are a major part of the natural ecosystem. Many insects are a benefit to Integrated Pest Management (IPM) programs. They help to control insect pest populations. Some growers buy beneficial insects solely for this purpose. Applicators must understand that beneficial insects can also be killed when pesticides are used to control insects. If the natural population of beneficial insects is decreased, the natural balance may be upset. Insect pests may quickly increase in numbers.

Applicators can protect beneficial insects by:

- Minimizing pesticide use
- Choosing pesticides that are least harmful to beneficial insects
- Leaving edges of treatment areas untreated to provide shelters for insect predators
- Reducing spray and vapour drift onto areas with beneficial insects

Pollinators such as bees are a special group of beneficial insects. Many plants need them in order to survive. Pesticide applicators can protect bees by:

- Telling nearby beekeepers and beekeeper associations when hazardous pesticides are going to be applied outdoors
- Not applying toxic pesticides to blooming crops
- Mowing cover crops and weeds to remove blooms before pesticide applications
- Choosing pesticides that are least harmful to bees
- Timing pesticide applications for when bees are not active (e.g., early morning or late evening)
- Reducing spray or vapour drift

Plants

Pesticides can injure target and non-target plants. Pesticides that damage or injure plants are said to be phytotoxic. Herbicides cause the most damage to non-target plants.

Applicators should refer to warnings on pesticide labels for non-target plant concerns.

Pesticides can affect non-target plants by:

- Drifting
- Runoff
- Leaching from treated areas or mixing, disposal, or storage sites

Applicators can protect non-target plants by preventing the movement of pesticides onto non-target areas.

Damage to streamside vegetation can affect bank stability and remove a food source and shelter area for wildlife. Loss of shade plants next to watercourses can increase water temperature and cause a loss of fish food. Increased water temperature may cause stress to fish, or result in their death. Damage to non-target vegetation can harm wildlife by affecting food sources or habitat.

In Review

Pesticide use can impact many parts of the land environment. This includes animals, beneficial insects, plants, soil and air. When using pest control products, applicators must respect and care for all aspects of the natural environment.

Contamination of soil and air by pesticides can be reduced by:

- **Complying with label directions and provincial laws**
- **Mixing and loading the pesticide with care**
- **Reducing drift**

Pesticides can directly or indirectly affect plants through:

- **Drift**
- **Runoff**
- **Leaching from treated areas, or mixing, disposal, or storage sites**

Animals can suffer adverse affects from direct exposure during a pesticide application. They can suffer indirectly when they consume or contact contaminated water, vegetation, soil, or food. Beneficial insects such as pollinators, insect predators, and decomposers can be killed, or their habitats affected, by exposure to pesticides.

Summary

Misuse or improper application of pesticides can contaminate or damage many parts of the natural environment. To reduce the risk of a pesticide, applicators must know how pesticides behave in the environment. They must know how, once released, pesticides can act to damage soil, water, air, plants and wildlife. When pesticides are applied, they can behave in a number of ways. Pesticides can be adsorbed, desorbed, or volatilized. They can also drift, run-off, degrade, or leach. This can harm non-target aspects of the environment.

Pesticide contamination of surface or groundwater can have a major impact on aquatic life. This can include:

- **Direct toxic effects on organisms**
- **Indirect effects on food supply, habitat, feeding, or mating**

Prevention is key to reduce the chance of contamination. Care must be taken to prevent pesticide from getting into waterways during transport, loading, mixing, or application.

Pesticide spray or vapour drift can contaminate the air and make it poisonous to humans, wildlife, and plants. A pesticide applicator who pays attention to weather and wind conditions can reduce the risk of air contamination.

Plants, beneficial insects, and wildlife can also be harmed by pesticides when they:

- **Drift**
- **Runoff**
- **Leach from treated areas or mixing, disposal, or storage sites**
- **Contaminate water, vegetation, soil, or food**

Following label recommendations, precautions, and buffer zones can reduce the chance of pesticides harming vital parts of the natural environment.

Self-test Questions

Answers are located in Appendix A of this manual.

1. Adsorption is the binding of chemicals to soil or other materials. List three (3) other processes that affect pesticides once they are released into the environment. Define each.

2. Explain how pesticides can contaminate water.

3. List three (3) ways to reduce contamination of watercourses and protect aquatic life.

4. List four (4) ways that pesticides can contaminate soil.

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5. List four (4) ways of keeping animals from being harmed by pesticides.

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6. What can happen if streamside vegetation is damaged?

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7. Which of the following is **False?**

   a. Aquatic organisms can be harmed <u>indirectly</u> when low-level contamination kills food organisms, removes aquatic or streamside vegetation, or disrupts mating or feeding.

   b. Once the pesticide is in the air, it can move to water bodies, non-target organisms, nearby crops, or soil.

   c. Non-point source contamination occurs when a large amount of pesticide is released in a small area (e.g., spill, pesticide fire, or poor disposal).

d. When surface water is contaminated, any animal or plant living in the water or using it can be affected.

8. Spray drift is the movement of vapours from the area of application. **True or False**?

9. The smaller the droplets, the more likely they are to drift. **True or False**?

10. To reduce the likelihood of spray drift, applicators should select nozzle types that produce small droplets. **True or False**?