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Environmental Considerations When Applying Pesticides

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Pesticides can be helpful in dealing with pests in our environment such as controlling invasive plant species that threaten native habitats or insects and diseases that attack our crops. Pesticides can also pose risks to the environment, especially when they are used improperly. Pesticide use and drift can affect air quality and pesticides in the food chain can threaten wildlife and people. In addition, pesticides are may be non-point sources of water pollution. As pesticide applicators, it is important to do your job carefully by both controlling pest populations and at the same time protecting the environment from the potential adverse effects of pesticide use.

Weather-wise application can help reduce pesticide hazards to the environment. A wise applicator carefully checks the weather conditions before beginning applications. A few simple precautions can help protect the environment, and save money. Pesticides which do not reach or remain on the target area are wasted. More pesticide, time, and money must be used to control the pests in the target area.

Goals of This Module

- Understand the dangers of pesticides in the environment and how to prevent environmental damage.
- Be familiar with how pesticides pollute groundwater and what steps can be taken to prevent it.
- Understand how pesticides persist in the environment.
- Understand the hazards of windy day application and who is legally responsible for mistakes.
- Learn the advantages of early morning or evening application.
- Understand the roles of humidity and temperature inversion in regard to pesticide application.

Pesticides in the Environment

Humans require a place to live with clean air and water, food which is not harmful, and an environment which will not threaten our health and safety. Since we share this planet with many other living creatures, we also have an obligation to protect the earth's resources from degradation. Few people will argue with the statement that pollution will grow as our planet's population grows. Population increases will require more food, fiber, and building materials and will create an increasing demand on the earth's finite resources.

Pesticides enhance public health and the environment when they are used properly and wisely. For example, they have been used to control pests which could be harmful to man. Rats carrying diseases or mosquitoes carrying Zika virus are two good examples. These control programs are necessary, especially in crowded cities and countries with large numbers of people. However, pesticides can also harm public health and the environment. Any pesticide which is off-target is a pollutant and can be dangerous. The benefits of pesticide use can be countered through misuse and/or carelessness.

Wildlife and Endangered Species

Wildlife. Fish, birds, and mammals are an essential part of the natural ecosystem. Parks, farmland, lawns, golf courses, etc., generally provide habitat for wildlife, as well as surrounding wooded areas and waterways. Therefore, care should be taken to protect these areas when applying any pesticide.

Endangered Species. Certain plants and animals have been identified as endangered or threatened species. An endangered species is one on the brink of extinction throughout all or a significant portion of its range. A threatened species is one likely to become endangered. The major threat to most wildlife is the destruction of habitat, usually the result of industrial, agricultural, residential, or recreational development. If wildlife habitat is threatened or destroyed by incidental exposure to pesticides, the wildlife is in danger as well. Reproduction of fish and wildlife can be affected by sublethal doses of pesticides in diets. Since all living things are part of a complex, delicately balanced network, the removal of a single species can set off a harmful chain reaction affecting many others, thus recovery is difficult or perhaps even impossible. It has been estimated that a disappearing plant can affect up to thirty

other species, including insects, higher animals, and even other plants that depend ultimately on that plant.

EPA has estimated that approximately 900 U.S. counties are known to contain endangered species. Pesticides can be harmless to wildlife when used carefully and on target. Every effort must be made to avoid causing harm to these important populations.

Honeybees. Honeybees help pollinate commercial crops and home gardens. The particular pesticide and the application method can reduce the chances of bee kills. Pesticides should not be applied to, or allowed to drift to crops in bloom. Shade trees and weeds should not be sprayed during bloom. Mow cover crops and weeds to remove the blooms prior to spraying. At the time of application, weeds in bloom also may attract bees to the area, increasing the chances of bee kills. Ideally, pesticides should be applied when there is no wind and bees are not "working" plants in the area. Damage can be minimized if the application is made late in the afternoon with a spray that breaks down within hours. In general, evening applications are the least harmful to bees.

Do not treat near hives. Bees may need to be moved or covered before applying pesticides near colonies. Do not let spray drip and form puddles or accumulate in wheel tracks. General area-wide application of pesticides may be harmful because bees cannot avoid contact with the spray on flowers or in water. Thus, the total wild bee loss may be sizable.

Check the product labels for specific bee hazards. Select the pesticide that is least harmful to foraging bees. Avoid using formulations that are harmful to bees. Dusts present more of a hazard to bees than sprays. Wettable powders are usually more hazardous to bees than either emulsifiable concentrates or water soluble formulations. However, microencapsulated insecticides are minute capsules that bees can carry back to the hive just like pollen. These capsules of poison are distributed throughout the hive affecting much of the colony. Ultra-low volume applications of some materials are sometimes more toxic than regular sprays. Granular formulations are generally the safest for bees. Some states have bee protection regulations in effect. Check with the state regulations section for details.

Food and Pesticides

With the help of pesticides more food per acre can be produced. Diseases, insects, and other plant pests can be greatly reduced. There can be higher yields and better crop quality. Overdoses of pesticides, which remain for a long time in the soil, can ruin good farm land making it unfit for crops. The crop may absorb the pesticides from the soil and can be over tolerance level at harvest. The pesticide may kill all or most plant life and make the land useless for farm or recreational use. Applying above labeled rates of pesticide increases the chance of illegal pesticide residue in crops and food, and could result in an unacceptable health risk to the consuming public. Finally, applying pesticides at higher than labelled rates is a violation of state and federal law.

Food Chain. Wildlife has an important place in the food chain. The food chain characterizes how animals and plants are interdependent. Each animal has a place in the chain based on the type of food consumed. Animals that consume plants are near the bottom of the chain. Animals which eat these plant-eaters are on the next level. Carnivorous animals are at the top of the chain. Application of pesticides over broad areas may eliminate certain needed food sources. Elimination of food sources can cause wildlife to relocate to other areas, substitute other food sources, or die. Wildlife moving to another area can create additional competition for food and space with resident species. A predatory animal lacking prey may shift to a valued game species or even domestic livestock. Fish and wildlife can be exposed to pesticides by eating animals poisoned by pesticides or plants containing pesticides. Also, this pesticide transfer could occur with birds feeding on insects, earthworms, etc. In this complex food chain each animal has an important place.

Accumulative Pesticides. Some pesticides can build up in the body of animals (including man). These pesticide accumulations can reach a level where health is affected. With a steady diet of plants or animals that are carrying pesticides, predators can accumulate these pesticides as well. This is how pesticides slowly accumulate in the food chain. Since mankind is at the top of the food chain and meat consumption is fairly high, people could be carrying higher levels of pesticides than other animals.

Non-accumulative Pesticides. The pesticides that do not build up in the body of animals or in the food chain are non-accumulative. These pesticides break down rapidly into other relatively harmless materials. For example, organophosphate pesticides initially have high toxicity and pose hazards. Because they do not accumulate in most biological systems, they are generally not as dangerous to the environment as other chemicals. Usually pesticides that degrade quickly are less harmful to the environment.

Pesticide Persistence

Persistent Pesticides. Persistent pesticides remain in the environment for a long time without breaking down. Although they can be useful for long-term insect, disease, or weed control, sometimes they last in the environment indefinitely. Persistent pesticides do not necessarily accumulate in animal bodies or in the food chain, but they could injure or kill plants in the vicinity afterwards. Some pesticides persist in the soil but do not seem to build up in

animals. For example, atrazine, a popularly used agricultural herbicide does not bioaccumulate, yet it is a persistent pesticide. The persistent nature of some pesticides is used to our advantage. Termiticides are used to protect wood in buildings from termite attack. They are both expensive and difficult to apply. It is therefore desirable for the termiticide to be persistent, protecting the building for a long time after only one application.

Microbial degradation. Some pesticides are destroyed in soils by microbial degradation. This occurs when microorganisms such as fungi and bacteria use a pesticide as food. Microbial degradation can be rapid and thorough under the proper soil conditions. Conditions that favor microbial growth include warm temperature, favorable pH levels, adequate soil moisture, aeration, and fertility. Adsorption also influences microbial degradation because adsorbed pesticides are less available to microorganisms, and they therefore degrade slowly. Certain pesticides require higher application rates to compensate for the pesticide lost through microbial degradation. In an extreme case of accelerated microbial degradation, pesticides that are normally effective for weeks suddenly become ineffective within days. In such a case, previous pesticide applications may have stimulated the buildup of certain microorganisms that were effective in rapidly degrading the pesticide.

Chemical degradation. Chemical degradation is the breakdown of a pesticide by processes not involving a living organism. The adsorption of pesticides to the soil, soil pH levels, soil temperature, and soil moisture contribute to the rate and type of chemical reactions that occur. Many pesticides, especially the organophosphate insecticides, are susceptible to degradation by hydrolysis in high pH soils or spray mixes.

Photodegradation is the breakdown of pesticides by sunlight. Pesticides applied to foliage, soil, or structures vary considerably in their stability when exposed to sunlight. Like other degradation processes, photodegradation reduces the amount of chemical present and lowers the level of pest control. Mechanical incorporation into the soil during or after application, or by irrigation water or rainfall following application, can reduce pesticide exposure to sunlight.

Air and Pesticides

Air is a necessity of life and is a source of oxygen for breathing as well as receiving carbon dioxide waste. Air has the ability to move particles for long distances. Most of the time this ability aids mankind. It causes rain, for example. Unfortunately, for the pesticide applicator this same ability is the cause of drift. Pesticide drift is the physical movement of a pesticide through the air at the time of pesticide application, or soon thereafter, from the target site to any off-target site. Pesticides in the air are not controllable and may settle into waterways, homes, lawns, wooded areas, etc. Drift must be avoided.

Controlling drift is important for the commercial applicator as well as the private applicator. To be effective, pesticides must be applied precisely on target at the correct rate, volume, and pressure. Drift from the target area may injure people, pets, wildlife, and sensitive plants. Drift of herbicides can damage nearby crops, forests, or landscape plantings. Poorly timed applications can kill bees and other pollinators which are working in the area. Beneficial parasites and predators that help control pests may also be killed. Drift can also be a problem indoors. Pest control operators must be aware that forced air heating systems and air conditioning units can move misapplied pesticides.

Particle Drift. Particle drift is influenced by many factors. Particle size, nozzle design and orientation, pressure, temperature, humidity, evaporation, height of release, air velocity and movement are among several important considerations.

Particle and droplet size. The smaller the particle size, the greater the potential for drift. Dust formulations are made of small particles and have a greater potential for drift than granular formulations. Small liquid droplets, especially those under 100 microns, also tend to drift more than large droplets. Whenever practical the applicator should use the largest droplet size in obtaining effective pest control.

Nozzle type, orientation and size. In terms of liquid drift control, the nozzle is probably more important than pressure. All nozzles produce a range of droplet sizes. Nozzles which produce small (fine) droplets should be avoided in drift-sensitive situations. Drift reduction nozzles minimize spray drift and should be used for applications in drift-sensitive situations. Placement of the nozzle in the air stream, especially where airblast and aerial application equipment are concerned, also affect droplet size. Nozzles pointed across the air flow produce smaller droplets. This is caused by wind shear.

Pressure. Droplet size is influenced by pressure. Some equipment operators will correct drift by varying pressure. The higher the pressure, the smaller the droplet. With smaller droplets better coverage may be gained resulting in higher chemical performance but at the expense of drift control. Because larger droplets are heavier and more difficult to move off target, reducing the pressure will help control drift.

Height of nozzle. Nozzles positioned too high will disperse spray over a wider area. This will also increase the likelihood of drift because spray particles must fall over a greater distance. The applicator must decide the desired

swath width by striking a balance among nozzle spray angle, pressure, and height above the target. For example, if an operator increases the application pressure and the rate, but maintains the swath width, he should lower the nozzle to compensate for the increased pressure. Lowering the nozzle may require switching to nozzles with a wider spray angle.

Air movement. Both horizontal and vertical air movement can affect drift. Unless it is calm, most pesticide applications are subjected to constant air movement. Indoors, heating and air conditioning systems move air and can move pesticides. Outside, unpredictable changes in this air movement can happen at any time to cause spray drift. Wind direction and speed directly affect the direction, amount, and distance of drift.

Temperature and Humidity. The rate of droplet evaporation is determined to a great degree by temperature and humidity. A droplet that evaporates before reaching the target does not control pests.

Vapor Movement. A pesticide that has vaporized (evaporated) can be carried from the treated area by air currents. The movement of pesticide vapors in the atmosphere is called vapor movement. Vapor movement, unlike spray or dust drift, is related to the chemical properties of the pesticide. Unlike the drift of sprays and dusts that can sometimes be seen during an application, vapor movement is not visible. Vapor movement can be caused by vapor leakage. Fumigants and other volatile materials exert pressure on the environment around them. Like air in a balloon, they are actively trying to escape. Stopping vapor leakage from their containers is done by keeping them closed or sealed. Fumigation sites must also be sealed properly to keep the pesticide from leaking. Applying these materials with vapor tight equipment is important. Some herbicides in particular can volatilize and move from a treated area, reducing control of the target weeds and increasing the likelihood that non-target plants will be injured. Pesticide vapors inside a dwelling can also cause injury, particularly if the occupants are sensitive.

Application of a volatile pesticide should be avoided when conditions favor volatilization, such as high temperature. The vapor pressure rating of a pesticide may help the applicator know the volatility of a pesticide. However, pesticide labels usually do not have the vapor pressure rating. Labels will give warning statements that the applicator must be sensitive to. The following are examples:

- At high air or ground surface temperatures, vapors from this product may injure susceptible plants.
- Under very high temperatures, vapors from this product may injure susceptible plants in the immediate vicinity.
- Off- site movement of spray drift or vapors of this product can cause foliar whitening or yellowing of some plants.

What can be done to avoid drift?

- Apply the largest effective droplet size.
- Use the lowest practical pressure.
- Choose nozzles that produce large numbers of large particles.
- Place nozzles with the air stream and not across it.
- Apply as close as practical to the target.
- Use a drift control additive.
- Do not apply when wind, temperature, or humidity are unfavorable.
- Choose non-volatile (those that do not vaporize easily) pesticide formulations.
- Increase the flow rates of your application (more gallons per acre).
- Consider establishing buffer zones.
- Consider using new technologies
  - » drift reduction nozzles
  - » spray shields
  - » electrostatic applicators
  - » air-assist spray equipment

Many factors interact to influence the distance material will drift from the target area. Even when common sense and good application technology are followed, drift can still be a problem for the applicator. Label instructions must be followed and strict attention must be given to the control of pesticide drift.

Avoid Windy Days

High winds increase drift and result in the loss of pesticide from treated areas. Drifting pesticides increase the possibility of injury to wildlife, pollinators, and domestic animals. They may settle on forage, pasture or wildlife areas or contaminate water. Pesticide application on quiet days reduces the inhalation and contact hazard to the applicator and the bystander. Drift onto sensitive crop areas can also be avoided in this way. The pesticide applicator is legally responsible for any injury or money loss due to pesticide drift onto non-target areas. Don't take a chance by spraying in the wind.

Other Wind and Temperature Considerations

The drift of pesticides is also affected by the air turbulence. The air turbulence is determined by the difference between the temperature at ground level and the temperature of the air above it. Normal weather conditions cause heating of the soil. If the air just above the soil is warmer than the air aloft, upward air currents begin. The larger the temperature

difference between air above the soil surface and the air aloft, the stronger the air currents. These air currents could carry spray droplets and pesticide particles a considerable distance away from the treatment area. Do not apply pesticides when such turbulent conditions exist.

An inversion occurs when the air near the soil surface is cooler than the air above it. The warm air forms a cap that blocks upward air movement that would otherwise help disperse the chemicals. Wind can aid in air mixing and reduce inversion conditions. However, low wind conditions during inversion conditions may cause small spray drops to remain suspended in the air. The droplets will eventually move out of the treatment area as a concentrated cloud. Smoke can be used as a good indicator of an inversion condition. Do not apply pesticides when inversion conditions exist.

Avoid High Temperature and Low Humidity Conditions

Temperature and humidity affect pesticide drift. High temperature and low humidity increase the rate of evaporation of the pesticide. Small droplets that completely evaporate leave pesticide particles in the air that may be carried several miles away from the treatment area (vapor drift).

Consider Early Morning or Evening Application

Wind speed is usually lowest and humidity higher in the early morning and evening, thus drift hazard is greatly reduced. Children and domestic animals are less likely to be in sprayed areas during these hours. Avoiding full daylight hours lowers the contact danger to wildlife such as birds, mammals, and pollinators, who often visit crop lands during the day.

Pesticides and Water Resources

Water is one of our greatest resources and is essential for all life. Man needs clean water for drinking, cooking, and bathing. Clean water is also essential to farmers who must feed livestock and irrigate crops. Half of the U.S. population and 90% of the rural population rely on groundwater for their drinking water. Groundwater makes up 96% of the world's total fresh water resource. Once considered to be safe from pollution, groundwater is now a threatened natural resource.

Groundwater and the Water Cycle. Groundwater is part of the water cycle. Groundwater is primarily stored in aquifers; geologic formations of permeable rock, sand, and gravel that contain enough water to yield usable amounts to wells and springs. Groundwater may come to the surface naturally at a spring or it may be drawn to the surface from a well. The cycle begins with precipitation such as rain or snow. Runoff from this enters surface waters, lakes, streams, and rivers. Some of this water seeps through the ground where moisture is drawn up by plant root systems. Water also moves downward through the soil (leaches) to become part of the groundwater. Water is then returned to the atmosphere through plant transpiration and evaporation from surface water, thus completing the water cycle.

Surface water results from precipitation, runoff, and the exchange of water from underground aquifers. Small streams flow and become rivers, gaining in water volume as the flow finds lower points along the waterway. The water gained along the way is often from a groundwater source. Where groundwater reaches lakes, streams, rivers or oceans it is released and becomes surface water. Streams can also lose water into the ground.

How Pesticides Pollute Groundwater.

Under certain conditions, contaminants including soil nutrients, wastes, and chemicals can migrate to groundwater sources. Pesticides applied correctly to a site may be moved downward with rain or irrigation water, reaching the water table below. This method of contamination is called non-point source pollution. Pesticides may enter a well directly from spillage or back-siphonage, thus entering the groundwater directly. This is called point source pollution. Because groundwater moves slowly, contaminants do not spread quickly. After pesticides reach groundwater they may continue to break down, but at a much slower rate because of less available light, heat, and oxygen. Thus, they can remain underground in slow-moving plumes for an indefinite period. When groundwater becomes contaminated, the polluted water may eventually appear in the surface water streams, rivers, and lakes. Because of the complex nature of groundwater, when the contamination is detected it is often widespread. Even if the contamination is stopped, it may take years before an aquifer can purify itself through natural processes. Once contaminated, groundwater is difficult and expensive to clean. Water from this source may be unusable for years. The best protection against groundwater pollution is prevention.

Factors that Affect the Fate of Pesticides in Water

Various processes affect the fate of pesticides following an application, disposal, or spill. The two basic processes are those that transfer chemicals or influence their movement, and those that degrade or break down chemicals. The primary transfer processes are adsorption, volatilization, runoff, leaching, and removal of treated crops or animals

from an area. The degradation processes are microbial, chemical, and photodegradation.

Adsorption. Adsorption is the binding of chemicals to other particles. Pesticide adsorption in soil depends on the pesticide properties, soil moisture content, soil pH (acidity), and soil texture. Soils high in organic matter or clay are the most adsorptive, while coarse, sandy soils that lack organic matter or clay are much less adsorptive.

A soil-adsorbed pesticide is less likely to volatilize, leach, or degrade. When pesticides are tightly bound to soil particles in highly adsorptive soil, they are less available for absorption by plants and microorganisms. However, soil adsorbed pesticides can be lost by erosion. Understanding adsorption factors can reduce damage to sensitive plants, leaching to groundwater, and the presence of illegal residues in a food or feed crops.

Volatilization. Volatilization is like evaporation. A solid or liquid can change its state and turn into a gas or vapor. For example, water left in an open pan volatilizes (evaporates) into water vapor and disappears. Some pesticides are very volatile. The volatility of a pesticide depends on its vapor pressure and temperature. The volatilization of pesticides increases with higher air temperature and air movement, low relative humidity and when spray droplets are small.

Runoff. Runoff occurs when water carries pesticides, either mixed in the water or bound to eroding soil, offsite. Rain carries pesticides off plant leaves to foliage near the ground and into the soil. The amount of pesticide runoff depends on the grade or slope of an area, the erodibility and texture of the soil, the soil moisture content, the amount and timing of irrigation or rainfall, and the properties of the pesticide.

Leaching. Leaching is the movement of contaminants, such as water-soluble pesticides or fertilizers carried by water downward through permeable soils. Several factors influence pesticide leaching. A pesticide that is easily dissolved in water moves with the water as it seeps through the soil. Soil structure and texture influence the rate and depth of pesticide leaching. Sandy and gravel soils have poor adsorption characteristics and allow water and pesticides to leach through quickly. A heavy clay soil does not allow for rapid leaching. Adsorption influences pesticide leaching because pesticides that are strongly adsorbed to soil particles leach less. NCRS is a good source of information on soil types, characteristics, and geological formations of your area. Leaching of pesticides from treated areas, mixing and rinsing sites, waste disposal areas, and manufacturing facilities is a major ground -water concern.

Groundwater Protection. Polluted water typically enters an aquifer in recharge water originating at the land's surface. Pollution can also be injected directly into an aquifer, for example, by back-siphoning directly into a well.

To minimize pesticide leaching to groundwater sources, consider the following steps:

- Read the label for any warnings.
- Evaluate the need, method, and frequency of pesticide use.
- Use alternative pest control methods whenever possible.
- Identify and know the vulnerability of the soil and leaching potential of the pesticide you are using.
- Consider the location of the pesticide application in relation to groundwater and surface water. Know the water table depth and the permeability of the geological layers between the surface and the groundwater. Be cautious around sinkholes or old wells because surface water easily reaches groundwater from these conduits.
- Reduce pesticide use and handling close to water wells. Groundwater contamination by pesticides or other pollutants can enter a well directly from the surface, through openings in or beneath a pump base, or through soil adjacent to the well. Well construction should be far from pollution sources. Avoid pesticide spills at all times and be especially careful in the vicinity of wells.
- Choose pesticides with the least potential for leaching into the groundwater. Look for characteristics which identify the pesticide as being insoluble, relatively instable, and readily adsorbed to soil.
- Follow directions on the label.
- Apply pesticides at the appropriate time.
- Measure the pesticide properly and carefully. Calibrate accurately and often. During calibration, check the equipment for leaks and malfunctions.
- Avoid spills and back-siphoning. The end of the fill hose should be held above the water level in the spray tank to prevent chemicals from back- siphoning into the water supply. Use an anti-backflow device (an air gap or check valve) when siphoning or pumping water directly from a well, pond, or stream. Some states require a mechanical anti-backflow device fitted on all filling equipment. Check the state regulatory section for details in your state.
- Accurately direct the application to the target site.
- Dispose of pesticides properly. Pesticides must be disposed of in accordance with local, state, and federal laws. Triple- rinse containers. Pour the rinsewater back into the spray tank to treat labeled sites or crops.
- Store pesticides properly in accordance with label directions. Pesticide storage facilities should be away from wells, cisterns, springs, and other water sources.
- Maintain records of pesticide use. Check with local and state regulations for record requirements.
- Comply with pesticide certification requirements.

Avoid Application Just Before Rains

Spray applications should not be made just before a rain, because the pesticide washes off and the pests are not controlled. Rains cause runoff and tend to wash the pesticide away from the target areas. The runoff can carry the pesticide into sensitive areas where crops or wildlife could be injured. Runoff can also reach surface waters such as farm ponds, streams and waterways. Ultimately, this can cause contamination, fish kills, and injury to domestic animals.

Do your part to aid the environment. Protect the environment by practicing proper pesticide use.

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