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IFAS EXTENSION

Factors Influencing Pesticide Movement to Ground Water 1

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In the past two decades, a great deal of new information has emerged about environmental consequences of pesticides. This publication covers much of that information.

Background

Prior to the late 1970s ground-water contamination from field-applied pesticides was virtually unexpected. It was assumed that pesticides in the natural environment would either break down or that the soil, sand, gravel, and rock formations would be adequate to cleanse water of its contaminants before it reached ground water. Now it is clear that human activities can lead to contamination of ground water.

The toxicity of pesticides makes them effective in controlling pests, but this toxicity means that pesticides must be properly applied and managed so that their potential to affect health and to contaminate the ground water is minimized. To reduce the risk of contaminating the ground water, it is essential to understand the factors that affect the behavior of pesticides in the natural environment.

Ground Water Facts

Ground water is the principle source of freshwater

for rural, industrial, and irrigation demands in Florida. Florida relies on ground water for 95 percent of its water supply.

Ground water is found in spaces between soil particles and rocks, and within cracks of bedrock. The water table is the name we give top of the saturated zone. Major reservoirs of ground water are called aquifers. Aquifers are recharged by rain, snowmelt, or interchange with surface waters. Ground water is not stationary, but moves vertically or horizontally following the slope of the water table.

Ground water may be contaminated by a variety of elements including domestic waste, nitrate nitrogen, bacteria, viruses, synthetic organic chemicals, heavy metals, petroleum residues and combustion products from roadways.

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1. This document is PI2, one of a series of the Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date June 1993. Revised April 1998. Reviewed April 2003. Visit the EDIS Web Site at <http://edis.ifas.ufl.edu>.
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Fate and Transport of Pesticides in the Environment

Once pesticides are applied to a site, a number of things may occur. The pesticide may be taken up by plants, evaporated into the atmosphere, carried off as drift, or ingested by insects, worms and microorganisms. The pesticide may adhere to soil particles or be dissolved in irrigation- or rain-water.

What happens to a pesticide depends on the pesticide and the site on which it is applied. When you study a map of the United States indicating where pesticides have been found in the ground water, and which pesticides have been found, you can see that some areas seem more vulnerable than others. You can also see that some pesticides reach the ground water more frequently than others do. There are several reasons why some sites are more vulnerable than others, and why some pesticides leach more readily than others.

Leaching and Site Vulnerability

Leaching is the vertical movement of water and solutes through the soil profile--as opposed to horizontal movement over the soil surface. There are four primary factors that affect the behavior of pesticides in the environment; these are:

- properties of the pesticide,
- properties of the soil,
- site conditions including rainfall and depth to ground water, and
- management practices, including method and rate of application, and irrigation practices.

These processes are dynamic and interrelated.

In states where soils are dense and there is slope, runoff of contaminants is a great concern. Leaching is a more serious concern in Florida, however, since most of the soils are sandy and, therefore, permeable.

Properties of the Pesticide

The fate of pesticides in soils is not determined by a single property of the pesticide but by a combination

of properties.

Information on chemical properties of pesticides is available from the manufacturer. It is not available on the pesticide label, although several pesticides (alachlor, aldicarb, atrazine, carbofuran, cyanazine, metribuzin, picloram, and simazine) have ground-water advisory statements on their labels because of their tendency to leach, or because they have been found in ground water.

Persistence

Persistence describes the staying power of a chemical. A pesticide that is persistent will maintain its structure, or stay a long time. Pesticides are broken down (degraded) at different rates by soil microorganisms, chemical reactions, and sunlight. If the soil is moist and warm, microbes use the pesticide molecules as a food source and turn them into harmless molecules such as carbon dioxide and water. Breakdown processes occur mainly in the root zone. Breakdown is considerably slower in deeper soils and sediments. Some pesticides form intermediate substances during the breakdown process which can be more toxic than the original compound.

Persistence is usually measured in terms of half-life

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how long it takes 50 percent of the original amount applied to become biologically inactive or broken down. The longer the half-life, the more persistent the chemical. Residues of persistent pesticides may be long lasting in the root zone or they may leach (move downward). Pesticides will continue to degrade upon reaching ground water. However, breakdown is generally much slower.

Adsorption

Persistence and adsorption are the two most important characteristics of a pesticide, affecting its potential to leach to ground water. Adsorption describes how tightly a compound becomes attached to soil particles. Pesticides that are strongly adsorbed (tightly held) will be less mobile in soil that is leached with water and will be less likely to reach ground water.

Some pesticides may be too tightly adsorbed to give proper pest control. Injury to sensitive rotational crops may sometimes occur when a pesticide used on the previous crop is later released (desorbed) from the soil particles in amounts great enough to cause injury.

Solubility

Solubility is the tendency of a chemical to dissolve in a solvent. It is another property that affects the behavior of a pesticide in the soil. As water percolates through soil, it carries water-soluble chemicals with it. This process is called leaching. The higher the water solubility value, the more soluble the chemical. For instance, a pesticide with a water-solubility value of 33,000 ppm at 80° Fahrenheit (27° Celsius) is much more water-soluble than a pesticide with a water-

solubility value of 33 ppm at 80° Fahrenheit (27° Celsius). It is also more likely to leach.

Solubility values for pesticides can be obtained from the *Farm Chemical Handbook*, published by Meister Publishing Company or from Material Data Safety Sheets (MSDS), obtainable from pesticide dealers.

Volatility

Volatility is the tendency for a liquid or a solid to change into a gas. Volatility describes how quickly a liquid will evaporate when it is in contact with air. Highly volatile chemicals are easily lost to the atmosphere. Some pesticides, such as fumigants, must be volatile in order to move and provide uniform distribution through the soil profile.

Properties of the Soil

Permeability

Permeability is a measure of how fast water can move vertically through the soil. It is affected by the texture and structure of the soil. Soils with coarse sandy textures are generally more permeable. Soils with higher permeability have greater potential for ground-water contamination than less permeable soils.

Soil Texture

Soil texture describes the relative percentage of sand, silt and clay.

Soil Structure

Soil structure describes how the soil is aggregated. Uncompacted soils allow more water flow. Soils with a loose structure or soils with hollow channels such as dried root channels or animal or worm tunnels, will also allow for increased flow of water through the soil profile. Soils that permit rapid flow of water through the soil profile present a higher potential for ground water contamination than less permeable soils. Sandy soils with their coarse textures and low water-holding capacity will allow for greater infiltration than finer, heavier clay soils.

Organic Matter

Organic matter is the single most important factor affecting adsorption of pesticides in soils. Organic matter content of soils may be increased by the addition of manure and incorporation of crop residues. Many pesticides are adsorbed (bound) by soil organic matter, which reduces their rate of downward movement. Soils high in organic matter tend to hold more water, which may make less water available for leaching.

Soil Moisture

Soil moisture affects how fast water will travel through the soil. If soils are already wet or saturated before rainfall or irrigation, excess moisture will runoff. Soil moisture also influences pesticide breakdown.

Site Conditions

Information about soils and the geohydrology of a site is available in county Soil Survey Reports published by the Soil Conservation Service for most counties in Florida.

Rainfall

Intense or sustained periods of high rainfall may cause large amounts of water to move through the soil, especially where little run-off occurs. Avoid using pesticides prior to heavy rain or irrigation.

Depth to Ground Water

Depth to ground water is a primary factor affecting the potential for pesticides to reach ground water. If the top of the water table is shallow, pesticides have less distance to travel to reach ground water.

Sinkholes and Bedrock

The presence of sinkholes, cracked bedrock, or confining layers in the bedrock significantly affects vertical movement of water. Sinkholes, cracked bedrock, and gravel soils allow dissolved pesticides to freely move to ground water as long as there are no confining geologic layers. Sinkholes present a high risk for ground water contamination by pesticides if runoff from fields where they are applied reaches them. Once water enters a sinkhole, it receives little filtration or chance for degradation.

Management Practices

Many application and irrigation practices affect a pesticide's potential to leach through the soil profile. The following is a list of general precautions to prevent ground water contamination by pesticides. For more detailed information see IFAS Pesticide Information sheet: Best Management Practices to Protect Ground Water from Agricultural Pesticides.

- Select Pesticides that are less likely to leach.
- Do not exceed recommended application rates.
- Calibrate application equipment to applied desired rate.
- Use Integrated Pest Management (IPM) to manage pests with a variety of strategies.
- Mix and load pesticides carefully; prevent spills.
- Do not apply a pesticide immediately prior to irrigation or a heavy rain.
- Do not overirrigate.
- Follow label directions for pesticide storage and disposal.

Conclusion

Protecting ground water is only one part of safe pesticide use and safe pesticide use is only one part of ground-water protection. Ground water can be contaminated by sewage, livestock waste, applied fertilizer, industrial practices, home chemical use, and other activities. Ground-water contamination from pesticides may result from normal land application, mixing and loading, back-siphoning into irrigation wells during chemigation, direct channeling of pesticides through sinkholes or poorly constructed wells, or by improper disposal. Pesticides must be handled safely not only to protect ground water but also to ensure human, livestock, wildlife, and environmental safety.

Purification of contaminated ground water is difficult. Treatment of contaminated ground water is expensive and--depending on the contaminant-- may not always be successful. The best policy is to prevent hazardous substances from getting into ground water in the first place.

Ground water is Florida's most important natural resource. It provides agriculture, industry and households with a vast supply of clean water. We need to ensure that this supply continues to be of high quality in the future by using wise management now. The best means of protecting the ground water supply is to understand how human activities may affect this important resource.

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