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Fate of Pesticides in Soils and Waters

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Pesticides are important to the success of Alabama agriculture as well as being important in helping maintain good public health. Over the years, the use of pesticides has greatly increased. During the past two decades, however, this increase has caused great concern over the presence of pesticides in the environment and the threat they may pose to wildlife and humans.

Although pesticides are indispensable in modern agriculture, their use and misuse can lead to serious water quality problems. Fish kills, reproductive failure of birds, and acute illnesses in people have all been attributed to the ingestion of pesticides or exposure to pesticides. Usually this is the result of misapplication, careless storage, or careless disposal of pesticides and containers. Groundwater contamination, however, is a potential problem following normal pesticide use.

Once a pesticide is applied, several things may happen. It may be taken up by plants and/or ingested by animals, insects, worms, or microorganisms in the soil; it may move downward in the soil and adhere to soil particles, or it may dissolve; it may volatilize; it may be broken down into less toxic compounds; it may be leached or moved out of the plants' root zone by rain or irrigation water; or it may be carried away by runoff water or erosion.

Factors Affecting Fate Of Pesticides

There are four major factors which affect the fate of pesticides. They are as follows:

1. Properties of the pesticide.
2. Properties of the soil.
3. Conditions of the site.
4. Management practices.

Pesticide Properties

Pesticide properties which affect movement to groundwater include solubility, adsorption, volatility, and degradation.

Solubility: Chemicals which dissolve readily in water are said to be highly soluble. As water seeps downward through the soil, it carries with it water-soluble chemicals. This process is called leaching. Highly soluble pesticides, therefore, have a tendency to be leached from the soil to groundwater.

Adsorption: Many pesticides do not leach because they are adsorbed or tightly held by soil particles. Adsorption depends not only on the chemical, but also on the soil type and amount of soil organic matter present.

Volatility: Highly volatile chemicals are easily lost to the atmosphere, similar to the evaporation of water. If a pesticide is highly volatile and not very water soluble, it is likely to be lost to the atmosphere, and less will be available for leaching to groundwater. Highly volatile compounds may become groundwater contaminants, however, if they are highly soluble in water.

Degradation: Another chemical property affecting leaching potential is the pesticide's rate of degradation in the soil. Pesticides are degraded, or broken down into other chemical forms, by sunlight, microorganisms in the soil, and a variety of chemical and physical properties. The longer the compound lasts before it is broken down, the longer it is subject to the

forces of leaching. Many chlorinated hydrocarbons are highly persistent in soil, but they have not been found in groundwater because of their low solubility and strong adsorption to soil particles.

Soil Properties

Soil properties affecting the movement of pesticides include soil texture, soil permeability, and organic matter content.

Soil Texture: Soil texture is determined by the relative proportions of sand, silt, and clay. Texture affects movement of water through soil and, therefore, affects the movement of dissolved chemicals, such as pesticides. The coarser the soil, the faster the movement of the percolating water, and the less opportunity for adsorption of dissolved chemicals. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer. These soils also have far more surface area on which pesticides can be adsorbed. The coarser the texture of the soil, the greater the chance of the pesticide reaching groundwater.

Soil Permeability: Soil permeability is a measure of how fast water can move downward through a particular soil. Water moves quickly through soils with high permeability. They also lose dissolved chemicals with the percolating water. In highly permeable soils, therefore, the timing and methods of pesticide application need to be carefully designed to minimize leaching losses.

Organic Matter Content: Soil organic matter influences how much water a soil can hold and how well it will be able to adsorb pesticides. Increasing the soil's organic content, through practices such as application of manure or plowing under of cover crops, increases the soil's ability to hold both water and dissolved pesticides in the root zone where they will be available to plants and to eventual degradation.

Site Conditions

The conditions of the site where a pesticide is applied can also affect the movement of the pesticide. Such conditions include the depth to groundwater, geologic conditions, and climate.

Depth To Groundwater: The shallower the depth to groundwater, the less soil there will be to act as a filter. Also, there will be fewer opportunities for degradation or adsorption of pesticides. Therefore, extra precautions need to be taken to protect groundwater in areas where it is close to the ground surface. In humid regions, groundwater may be only a few feet below the surface of the soil. If rainfall is high and soils are permeable, water carrying dissolved pesticides may take only a few days to percolate downward to groundwater. In arid regions, groundwater may be several hundred feet below the soil surface, and leaching of pesticides to groundwater may be a much slower process.

Geologic Conditions: In addition to depth to groundwater, it is important to look at the permeability of the geologic layers between the soil and groundwater. Highly permeable materials, such as gravel deposits, allow water and dissolved pesticides to freely percolate downward to groundwater. Layers of clay, on the other hand, are much less permeable and, thus, inhibit the movement of water. Groundwater quality is most vulnerable in areas where permeability of geologic layers is rapid.

Climate: Areas with high rates of rainfall or irrigation may have large amounts of water percolating through the soil and, therefore, are highly susceptible to leaching of pesticides, especially if the soils are highly permeable.

Management Practices

Management practices include the method used to apply the pesticide and the rates and timing of application.

Application Methods: Another factor determining leaching potential is the way in which a pesticide is applied. Injection or incorporation into the soil, as in the case of nematicides, makes the pesticide most readily available for leaching. Most of the pesticides which have been detected in groundwater are ones which are incorporated into the soil rather than being sprayed onto growing crops.

Pesticide Rates And Timing: The rate and timing of a pesticide's application also are critical in determining whether it will leach to groundwater. The larger the amount used and the closer the time of application to a time of heavy rainfall or irrigation, the more likely that some pesticide will leach to groundwater. Particular care should be taken when practicing chemigation because of the risks of back-siphoning and leaching.

Good Management Practices

Good management practices can help prevent unwanted pesticide movement. There are several good management practices to consider when working with pesticides. They are as follows:

1. Follow pesticide label directions.
2. Mix pesticide and calibrate equipment accurately.
3. Avoid spills and back-siphoning.
4. Dispose of pesticide wastes and containers properly.
5. Eliminate unnecessary pesticide applications and use other pest control methods if possible.
6. Consider such factors as the weather, soil type, location, timing, and application methods before applying pesticides.
7. Irrigate properly by controlling the quantity and timing of irrigation.
8. Use proper pesticide storage.
9. Always maintain records of pesticide use.

For more information, call your county Extension office. Look in your telephone directory under your county's name for the number.
