The Environmental Fate Of Pesticides

A working knowledge of what happens to applied chemicals is essential for superintendents to answer questions.

In this day and age, the environmental soundness of a golf course is constantly being questioned. Whether the course has been in existence for decades or is simply being proposed, concern over the use of fertilizers and pesticides dominates much of the public's attitude toward it. One-sided mass media coverage of pesticide use in general has helped fuel much of that concern. Unfortunately, occasional instances of irresponsible abuses of pesticides on golf courses and other turf areas occur and only serve to fan the flames of public outcry.

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Fertilizer and pesticide use on golf courses is necessary to provide a playing surface that is adequate to satisfy the requirements of the game. Proper choice and use of fertilizers and pesticides is fundamental to sound management strategy and provides the backbone to which other maintenance practices are connected.

At the focal point of fertilizers and pesticides is the golf course superintendent, who makes the decisions concerning their use. As a result, it is incumbent on superintendents to be as conversant and literate about fertilizers and pesticides as possible. Central to the issue of pesticide literacy is having a working knowledge of pesticide fate. With this knowledge, golf course superintendents can appropriately answer questions about pesticides and the environment, whether the questions are posed by a golfer, a club official, local citizens or even members of the media.

Common Perception

Most people assume that when fertilizers and pesticides are applied to golf courses they either move off the site in runoff water or move downward with percolating water until coming in con-

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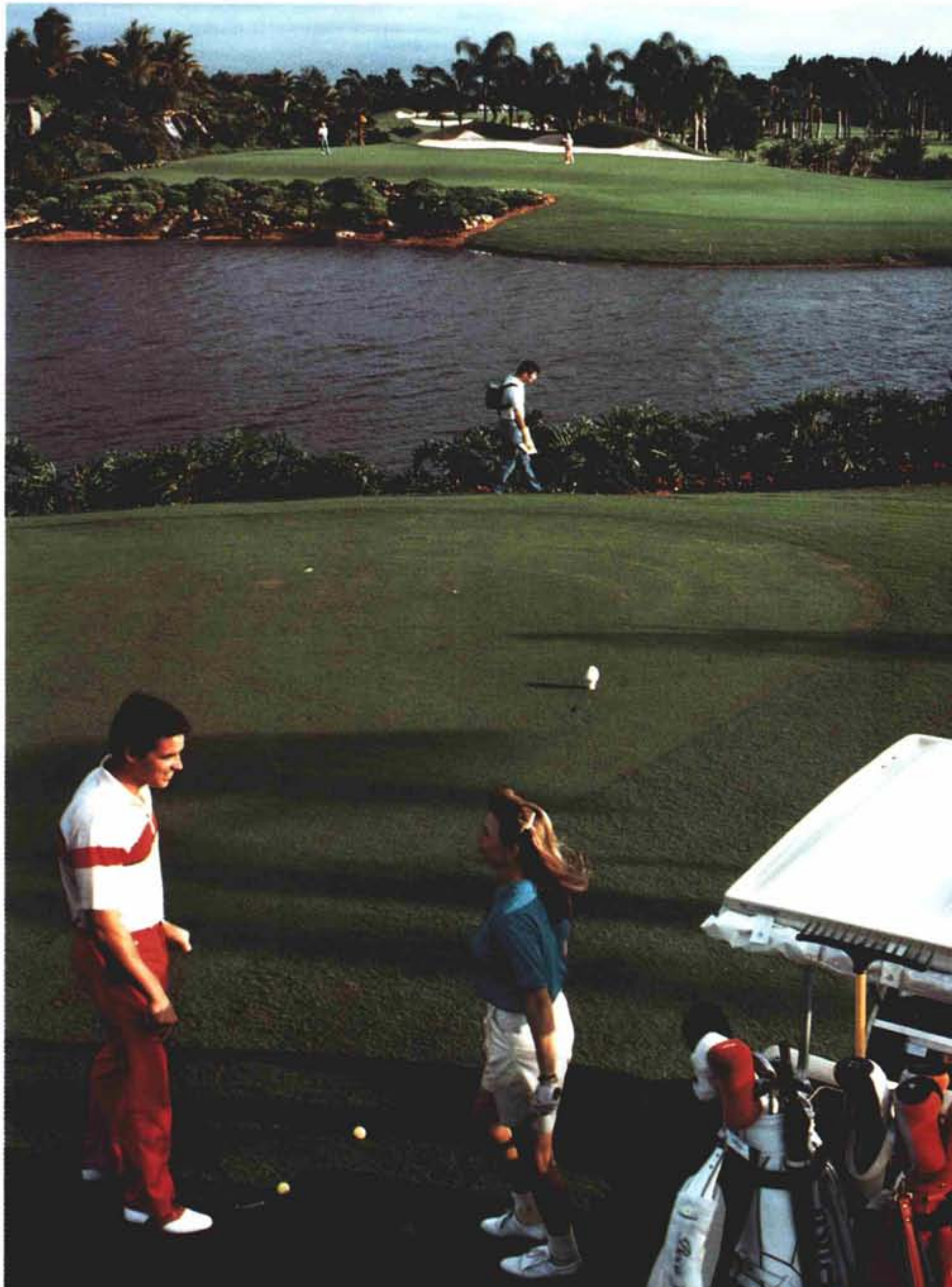

The richness and complexity of the golf course environment are manifested in many different ways on each individual course. An understanding of the variables involved can help superintendents work to address members' and public concerns about the fate of pesticides applied.

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tact with groundwater. One or both of these possible fates may take place; however, several other possibilities also exist.

What Can Happen After Application

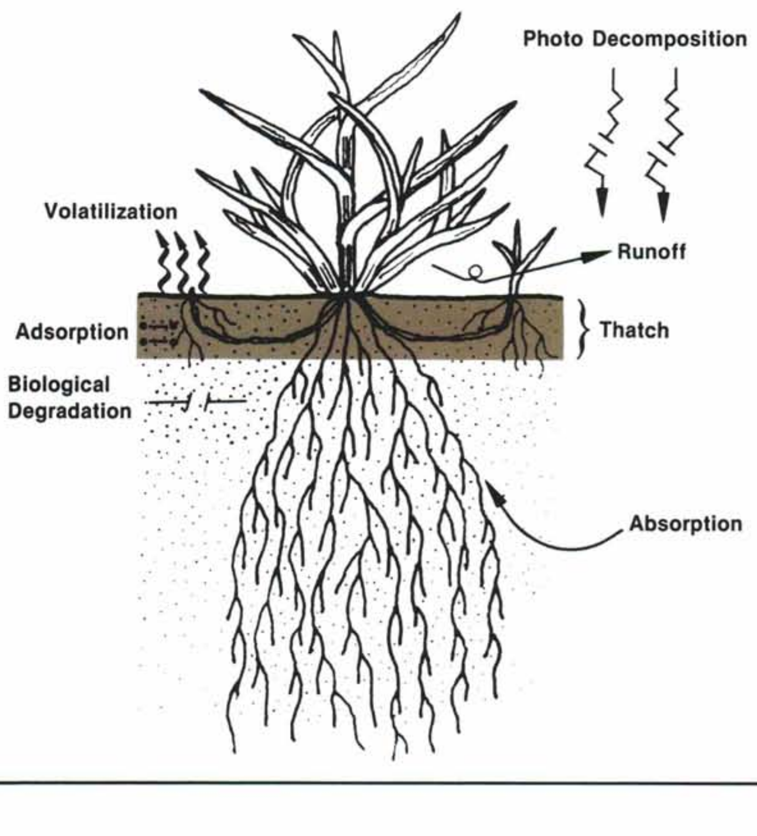
To use a chronolgical approach to discussing pesticide fate, we will assume that a pest has been identified and that the appropriate pesticide has been chosen for the control of the pest. Assuming that a properly calibrated sprayer or spreader is used and that no drift or other off-site movement has occurred, the initial consequences of having introduced the pesticide to the site begins.

Adsorption. Adsorption is the binding of a chemical to the surface of plants or soil. This binding phenomenon is influenced by a number of factors: the nature of the surface, moisture, pH and the various physical and chemical properties of the chemical that has been applied. From a soil standpoint, those that are high in organic matter or clay tend to have the highest adsorptive capacity, and coarse, sandy soils low in organic matter are less adsorptive.

Adsorption is critically important as it influences the other fate processes. Any pesticide that is tightly adsorbed or bound to the soil or organic matter is less likely to volatilize, leach, be degraded by microorganisms or even be adsorbed by plants. Those chemicals having properties that lend themselves to strong adsorption have a very low potential to move in surface water; therefore, they pose little risk of pollution from runoff. Two such compounds are pendimethalin, a commonly used pre-emergence herbicide for the control of summer annual grasses, and chloropyrifos, a thatch active insecticide that is used for the control of chinch bugs and other thatch-inhabiting insects.

Research at Pennsylvania State University has shown that these two pesticides do not move in water, either off the site with runoff or down through the profile of a silt loam soil. Even when excessive amounts of water were applied, these two pesticides were never detected, even though the detectability level was one part per billion. Obviously, chemicals that are tightly adsorbed do not threaten water resources.

Processes Involved In Fate Of Pesticides In The Environment



Volatilization. Volatility — the state of being volatile, or readily vaporized — must be considered as a relative term because every substance is volatile under the right conditions. Under normal circumstances, however, most things are not volatile, at least not at detectable levels.

Regardless of whether a chemical is a solid or a liquid, it can change physical state at a given pressure. This pressure is referred to as vapor pressure, which is the point at which solids vaporize and liquids evaporate. Both solids and liquids increase vaporization as the temperature increases. Furthermore, pesticides formulated as esters have a much greater potential for volatility than do amine formulations. By adding side chain molecules, however, low volatile ester formulations are available when the need to use an ester formulation arises.

Pesticide volatilization also increases with high air movement and low relative humidity and is also favored by high soil moisture content. The best way to reduce potential volatilization losses is to use amine formulations; never use ester formulations when temperatures are above 80 to 85 degrees and the relative humidity is low.

Photodecomposition Of Pesticides. Sunlight transformation can be a significant environmental fate for pesticides, especially for those that are applied to the surface of plants and soils, a practice that is quite common on golf courses. The transformations brought about by the exposure of a pesticide to sunlight generally alter the chemical properties of the pesticide to the extent that it is less toxic and more susceptible for further environmental degradation by other chemical and microbial processes.

Any sunlight-induced transformation

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of a pesticide is the result of a highly complex set of responses to the absorption of radiation. When a pesticide that is susceptible to sunlight degradation absorbs radiation, an electronically excited molecule is the result. Molecules in such a state undergo various chemical and physical changes. Although all chemicals can absorb radiation of sufficient energy, sunlight wavelengths cause degradation of a small number of pesticides. However, photodegradation can be so significant that certain pesticides are only effective when applied as granular formulations or when incorporated into the soil.

Runoff. The movement of chemicals in runoff water or in the sediment carried by the runoff is a common fate of certain pesticides. Chemicals that are tightly bound to soil that is eroded and carried by runoff have a relatively high pollution potential. On established golf courses, movement of soil particles in runoff is almost non-existent, and the amount of water that actually moves from high quality (good stand density) sites is extremely small. Runoff research at Penn State has shown that, even under extreme conditions, the amount of water that moves from sodded sloped sites is very small.

In agriculture, when soil erosion caused by runoff from cultivated fields treated with pesticides is thought to be an environmental problem, the solution is to plant grass buffer strips between the treated fields and any nearby body of water. The grass buffer strip slows the overland flow velocity of the water, which allows the sediment (which contains most of the offending pesticide) to settle out, and the infiltration of water increases — thereby decreasing total runoff.

Applications of pesticides when soil moisture conditions are high and heavy rainfall is predicted can only serve to substantially raise the potential for the movement of pesticides in runoff. Sound management practices dictate that label recommendations always be followed and that good common sense be used.

Chemical Conversion. The hydrolysis of chemicals is another important fate of pesticides applied to land and water. Most chemical conversions that result as a specific fate of a pesticide occur in aquatic environments. However, adsorption-desorption processes that take place in the soil can modify the aqueous environment. Such processes can have significant effects on the relatively simply hydrolysis reactions that occur in aqueous environments. Little research has been done to document such effects, but the research that has been conducted indicates that the hydrolysis of pesticides can be either enhanced or reduced by the presence of mineral or organic absorbing surfaces. As further research is conducted, the ability to predict hydrolysis rates in field situations will continue to improve.

Absorption. The movement of pesticides into plants and, to a much lesser extent, into soil-borne organisms is referred to as absorption. Once absorbed by plants, most pesticides are degraded. When the plant dies the residue serves, in part, as an energy source for the soil microbiological population. In the case of most herbicides, absorption is the key environmental fate necessary for the pesticide to successfully control the pest. When weed control fails, one or more of the other possible pesticide fates has reduced the available dosage of the herbicide to the extent that control is not possible.

Biological Degradation. Much of the natural degradation of pesticides occurs because of the action of the microbiological population in the soil and thatch. In fact, current research into the genetic engineering of microbes that attack and degrade specific chemical groups is being actively funded by the Environmental Protection Agency. Encouraging results lead many scientists to think that the ultimate solution to the chemical cleanup of toxic waste dumps will be through the introduction of microbial populations that use toxic substances for an energy source (food).

Environmental conditions have a significant effect on the activity of the soil microbiological population. Warm, moist soil that is well-aerated and has a pH range of 6.5 to 7.0 promotes microbial degradation. Obviously, turfgrass management on golf courses can significantly enhance biological activity and promote the degradation of applied pesticides. Those management practices that promote good turfgrass growth and competitiveness are also those that enhance microbial activity, which is no coincidence.

Removal From The Site

The physical removal of pesticides from the application site is the final fate we will discuss. On the golf course, the most obvious source of this pesticide fate is the removal of clippings. When treated plants are moved from the site, any pesticide residues that remain are also removed.

Disposal of clippings on golf courses is accomplished in a variety of ways. Regardless of the disposal method, the potential for pesticide residues to be present on or in these clippings can be significant. Little research has been focused on the extent to which such residues exist or whether their presence could have negative environmental consequences. However, it is known that grass clippings that contain recently sprayed herbicides can negatively affect sensitive plants if the clippings are used as a mulch around such plants.

Golf course superintendents must be aware of the potential for the presence of pesticide residues on grass clippings, particularly in an age when clippings are being collected from more areas of the golf course then ever before. Storage and disposal of clippings should be as well thought out as any other part of the overall turfgrass management program. Because the primary means for the degradation of most pesticides is microbial activity, considerable emphasis should be placed on the potential that composting of clippings offers as an environmentally harmonious means for disposal.

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Increasing your knowledge of pesticide fate in the environment is only preparation for the next challenge — communicating that knowledge to others. The golf course superintendent is often looked on as the turfgrass expert in the community. Because the pervasive public attitude appears to be that golf courses contribute to the demise of the environment, it is incumbent on every golf course superintendent to be as environmentally conversant as possible. □