

# Potential Movement of Pesticides Following Application to Golf Courses

by DR. AL SMITH  
University of Georgia, Griffin, GA

CURRENTLY, there are more than 14,000 golf courses in the United States. Assuming an average size of 120 acres per course, there are more than 1.68 million acres of turfgrass in the golf course industry. If we assume that there are two acres managed as putting greens per 18-hole course, there are about 25,300 acres of golf course greens in the United States.

The National Golf Foundation estimates that there are 24.5 million golfers in the United States, and by the year 2000 the number of players could easily exceed 30 million. To keep up with both present-day needs and the rapidly increasing number of golfers, it has been suggested that a golf course must be opened every day for the next 10 years.

Although agriculture is by far the largest user of pesticides in North America, specialty turfgrass areas are typically the most intensively managed biotic systems. The public demand for high-quality turfgrass and uniform playing surfaces on golf courses often requires the use of intensive management strategies to control pests. These management practices on so many acres are resulting in increased interest by the general public concerning the environmental impact of these practices. A critical issue facing the golf course industry is the environmental fate and safety of pesticides used for management. The enhanced interest in pesticide use is, in general, a response to the increased use of pesticides since the 1960s, the advancements in technology that allow scientists to detect pesticide contamination at very low concentrations, and recent articles in the popular press such as the article "Poison in Your Backyard" (published in *Family Circle* magazine).

The public alarm raised about pesticides in the 1960s has been translated into legislative controls. This has resulted in more rigid testing of pesticides prior to their registration and attempts to restrict the use of certain pesticides by anyone other than trained applicators. Concern about human and environmental welfare has been an important concept behind this legislation, and the growing concern will ultimately result in more legislated controls on the use of pesticides. With increasing controls placed

on pesticide use, such as mandatory posting of the area to be treated, public inquiries will continue to increase.

A major concern about the impact of pesticides on the environment is their potential movement into drinking water sources that is facilitated by movement in surface water and groundwater from the treated sites. In response to this concern, a team of scientists at the University of Georgia developed a research program to determine the potential for pesticide movement following application to golf course greens and fairways. The research program was funded, in part, by the United States Golf Association. The initial research was conducted on simulated and miniature golf course greens that were constructed according to the United States Golf Association recommendations for putting green construction. These greens are designed and constructed for ideal infiltration and percolation of water through the rooting medium. The soil mix under the greens contained as much as 98% (wt/wt) sand, allowing for rapid water infiltration and percolation and an extremely low adsorption affinity for most of the pesticides. Therefore, one might expect the pesticides to move rapidly through the sod and enter the drainage water exiting the base of the green.

Lysimeters were developed in the greenhouse and in the field in order to collect the water leachate moving through the greens. The lysimeters were filled with the rooting medium, sand, and gravel according to USGA recommendations and covered with bentgrass or bermudagrass sod. Pesticide treatments were made to the sod, and irrigation and simulated rainfall events were applied through an automatic watering system. The field lysimeter installation was protected from natural rainfall events with an automatic closing/opening rain shelter.

Results of this research indicated that only small quantities of several herbicides — 2,4-D, dicamba, mecoprop (MCPP), and dithiopyr — were found in the water leachate moving through the greenhouse and field lysimeters. The concentrations of these herbicides in the leachate did not exceed 5 ppb (parts per billion), and the total quantity to exit the lysimeters was less than 1% of the applied herbicide. The insecticide chlor-

pyrifos (Dursban) and the fungicide chlorothalonil (Daconil) were not found in the leachate moving from the treated turf.

In summarizing the relevance of these results, it is necessary to identify the measurement units used. A part per billion (ppb) is equal to adding one teaspoon of table salt to 26 million gallons of water. Therefore, it is clear that the concentration of pesticides in the water leaving the treated greens is very small. The United States Environmental Protection Agency is currently developing drinking water standards for surface waters and groundwater supplies. The standards will be based on the same toxicological research used to establish reference doses for food. These standards will be maximum contaminant levels (MCLs) allowed for pesticide concentrations in potable water. The MCLs for only a few pesticides used on turfgrass have been recommended. The recommended MCL for 2,4-D is 70 ppb. The water leaving the lysimeters under the simulated greens contained less than one-tenth this concentration of 2,4-D, and it must be realized that this water would enter into a stream or water reservoir that would dilute the concentration by factors of tens of thousands.

The use of several models and mathematical equations used in agriculture to predict the movement of these pesticides through the greens indicated that at least 10-fold greater concentrations of the herbicides would be expected in the water leachate moving from the lysimeters. These mathematical equations were developed and validated for agricultural row crops, which is a very different situation than is found in a sod where most of the ground surface is covered by thatch. The initial distribution of the chemical applied to turfgrass ultimately determines the amount of pesticide reaching the intended target and the amount of pesticide that will be lost from the turf ecosystem after application. The most desirable scenario for the fate of a pesticide is for the pesticide to control the target pest and to be immediately degraded to carbon dioxide, water, and other basic molecules and/or elements. Probably the reason that there were such low quantities of pesticides found to exit the research lysimeters was due to the





*Field lysimeters, maintained as a green, used both bentgrass and bermudagrass. An automatic rain shelter protected the lysimeters from natural rainfall events.*

sequestering of the pesticides in the thatch and rooting regions of the sod, allowing for rapid degradation of the pesticide molecules. The extensive, fibrous root system of the sod and the moist conditions of a well-maintained green allow for elevated activity of microorganisms for degradation of the pesticides. This same condition would exist on greens at most golf courses.

In addition to the potential for pesticides to leach through the greens, there also is a potential for the pesticides applied to golf course fairways to enter into the surface waters (e.g., streams) that leave the golf course. We developed small plots to simulate golf course fairways. The bermudagrass sod was placed onto the sandy clay soil that is typical of the southeastern United States. The plot areas had a slope of 5% and drained into individual collection units designed to measure the total water runoff and to subsample the water for measuring the presence of the pesticides. Following application of the pesticides to the plots, simulated rainfall events were used to supply the water for runoff events. Treatment periods were selected that would allow for at least 48 hours without a natural rainfall event. The simulated rainfall was used at 24 and 48 hours after treatment, and natural rainfall events were monitored when they occurred.

Results of this research indicated that over a 25-day period following treatment of the simulated fairways with 2,4-D, meco-

prop, and dicamba, seven simulated and natural rain events occurred. An average of 42% of the rainfall water left the plots as runoff and approximately 8% of the applied pesticides left the treated plots in the runoff water over the 25-day collection period. Eighty percent of the herbicides that left the plots in the runoff water moved during the first simulated rainfall event. The rainfall was simulated to give a high-intensity storm event (2" per hour) for a total rainfall of 2". Although this is not an uncommon event for a summer thunderstorm in the southeastern United States, it is a high-intensity event.

These data would indicate that there is a need for additional improvement of the management strategies used on fairways to decrease the amount of pesticides leaving these areas during a rainstorm following application. There are several management strategies that can be adapted for decreasing the quantity of pesticides leaving in the runoff water. The amount of runoff water can be decreased by increasing the rate of water infiltration into the sandy clay soil through soil aerification, coring, and verticutting. A light irrigation following the pesticide application can be used to wash the chemicals from the foliage and soil surface into the soil profile. Generally, a 6-hour period following application of the pesticides used in this study is all that is required for maximum efficacy in pest control. Therefore, the

application could be made during a period that has a low chance of rainfall for a 12-hour period, and an irrigation application could be made at 6 hours after treatment so as not to produce runoff. This would place the pesticides in the thatch or grass root zones, and they would not move in the runoff water during a high-intensity storm event. This management strategy will be investigated in ongoing research.

The critical issue facing the research and regulatory institutions responsible for turfgrass management is the development and interpretation of data on the environmental fate and safety of pesticides used in the management of golf courses. The fate of pesticides following application can be measured, as we did, or estimated through use of mathematical models. However, safety cannot be measured, and human risk can only be estimated based on the toxicity of the pesticide and the degree of human exposure. Something is considered safe if its attendant risks are judged to be acceptable. It is commonly agreed that it would be desirable to have **zero** level of pesticides in our drinking water. However, analytical instruments used for measuring the presence of pesticides in air, water, and food are continually being improved so that we can detect smaller and smaller concentrations of the chemicals. In other words, yesterday's **zero** is no longer **zero**, and today's **zero** will not be **zero** tomorrow.