Pesticide Degradation Under Golf Course Fairway Conditions

by DR. G. L. HORST, DR. P. J. SHEA, and DR. N. CHRISTIANS
University of Nebraska and Iowa State University

GROWING CONCERN about hazards to and in the environment now extends into all areas of life. Many perceive runoff and leaching of fertilizers and pesticides from agricultural, municipal, and industrial operations as well as recreational areas, urban landscapes, and golf courses to be critical environmental problems. Golf course and recreational turf managers rely heavily on pesticides and fertilizers to keep turf and landscapes functional and aesthetically pleasing.

In Nebraska alone, an estimated 10,000 tons of fertilizer and 2,400 tons of pesticide are applied to recreational areas, commercial landscapes, lawns, and golf courses each year. Turf itself may play an important role in prevention of fertilizer and pesticide leaching. In order to protect groundwater from contamination by agrichemicals, one has to understand the relationship between pesticide degradation, solute (pesticide) leaching, and imposed management practices. Many factors influence what happens to fertilizers and pesticides once they are applied to golf course turf or lawn situations, including application timing, rate and total amount of agrichemicals, and water as rainfall and irrigation.

Encasement of the turf/soil column ensures an intact undisturbed profile for pesticide sampling.

Together with researchers at Iowa State University, Ames, the University of Nebraska, Lincoln, research team examined the fate of pesticides under golf course fairway conditions.

Research results indicate that turfgrass may actually promote pesticide degradation in the environment. The frequent irrigations employed to keep the grass green have been accused of contributing to pesticide leaching and runoff. On the other hand, the relatively high water content and nutrient rich environment in most turfgrass/soil systems may actually promote pesticide degradation, because pesticide availability and degradation rate generally increase as temperature and soil water content increase.

The research project initially examined the persistence and mobility of four commonly used pesticides: pendimethalin (Lesco 60 DG, Pre-M®) herbicide, metalaxyl (Subdue®) fungicide, chlorpyrifos (Dursban™), and isazofos (Triumph®) insecticides in turfgrass/soil systems. It was also of interest to determine the relative distribution of these pesticides among the verdure, thatch, and soil components with time after application.

Field Procedures

The field research was conducted in 1991 and 1992 at the University of Nebraska John Seaton Turfgrass Research Facility near Mead, Nebraska, and at the Iowa State University Horticulture Research Facility near Ames, Iowa. Each of the four pesticides was applied (late May to early June each year) to Kentucky bluegrass turf managed as golf course fairway. Intact turf/soil cores from a Sharpsburg soil (silty clay loam) and a Nicollet soil (fine-sandy loam) were removed to a 2 ft depth from field plots before application and 1, 7, 14, 28, 56, and 128 days after application. To maintain the integrity of the samples, the turf/soil cores were encased

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before removal from the field research areas. Pesticide fate and location in the turf/soil core profiles were determined through analysis of the turf/soil cores sectioned into verdure, thatch, and seven depth increments. Quantitative analysis of pendimethalin, chlorpyrifos, metalaxyl, and isazofos was by gas chromatography.

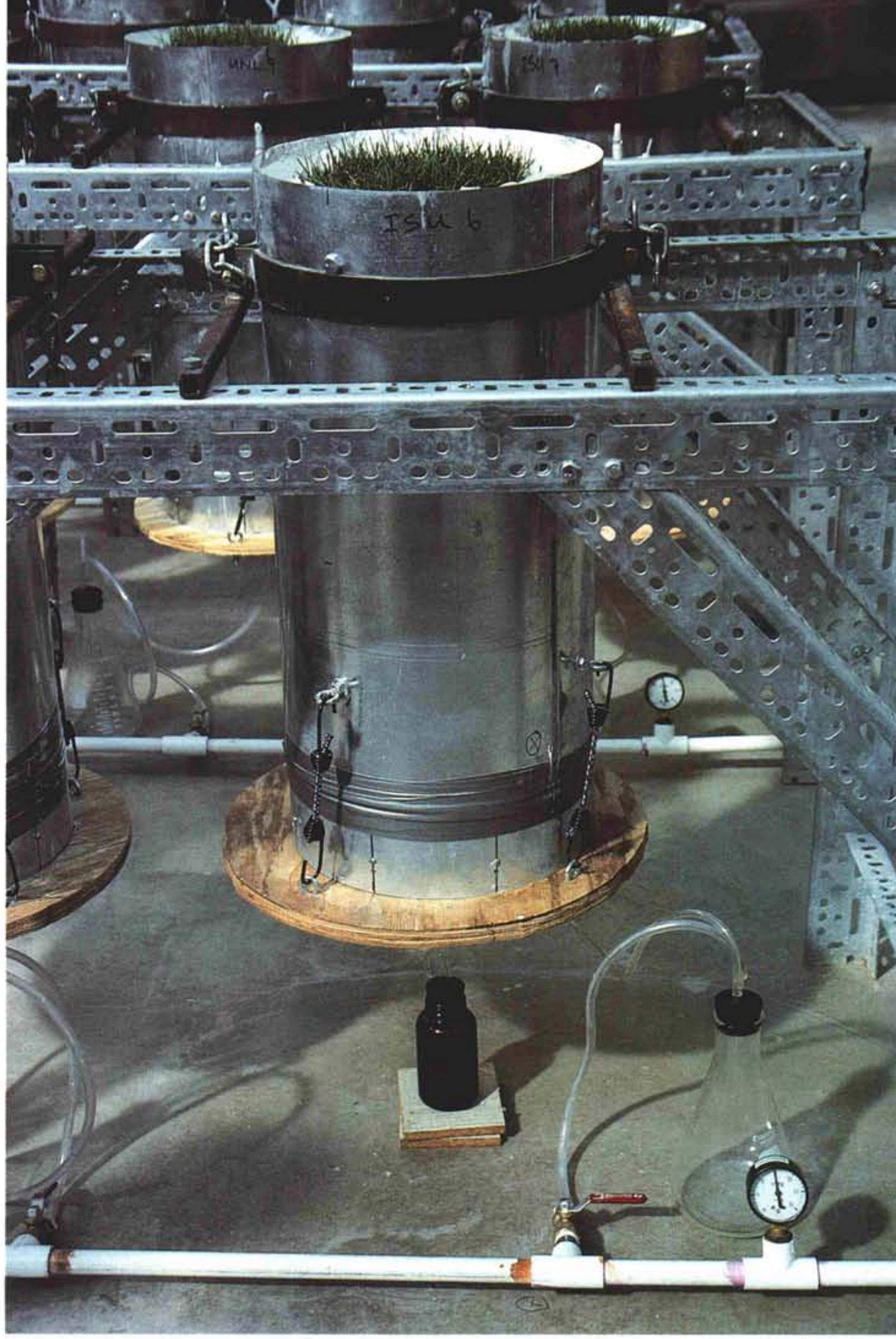
Conclusions

As expected, a compound's individual chemical properties, use location, and climatic factors influenced the level of pesticide residue measured in the turf/soil system. Statistical analysis indicated that years (1991 vs. 1992), the range in sampling times after pesticide application, and the turf/soil component (verdure, thatch, soil) were significant factors influencing pesticide fate and where the pesticides were detected in the turf/soil system (Figure 1). The year (1991 and 1992) factor includes such environmental variables as air and soil temperature, rainfall, irrigation, wind speed, and number of cloudy days. This means the fate of these pesticides will vary from year to year. One also would expect that sampling times for analysis of these pesticides would be significant as the pesticides degrade over time, and the results confirm this. Location (Nebraska and Iowa) influenced the total pesticide residue amounts of isazofos, chlorpyrifos, and metalaxyl detected. This may be due to differences in soil type and weather conditions. A lack of differences in pendimethalin residues between locations could be due to the low solubility and relative immobility of this herbicide.

Variability in isazofos residues indicated a greater response to soil type and to profile component differences such as thatch amounts and weather conditions. Greater amounts of metalaxyl were measured in the Nebraska turf/soil profile in 1991, while samples from the Iowa location had greater detectable amounts of the fungicide in 1992.

Chlorpyrifos levels varied by year of application and location, with more insecticide residues measured in 1992 at the Iowa location than at Nebraska. In contrast, pendimethalin residues were lower in the first year of the research, but differences between locations were smaller than measured for the insecticides isazofos and chlorpyrifos.

While turfgrass verdure contained relatively high concentrations of the chlorpyrifos and pendimethalin pesticides immediately after application, irrigation, rainfall, and mowing reduced the amount of pesticides recovered from the plant material with time. Seven days after application, the verdure contained 10%, 8%, 3%, and 2% of the total amounts of chlorpyrifos, pendimethalin, isazofos, and metalaxyl.



Encased soil profiles provide a method for measuring pesticide movement.

Table 1
Properties of Metalaxyl, Isazofos, Chlorpyrifos, and Pendimethalin*

Pesticide	Water Solubility (mg L^{-1})	K_{OW}	K_{OC}	Half-Life (days)	Vapor Pressure (mPa)	SCS Rating Leaching	SCS Rating Runoff
Metalaxyl	8400	50	50	70	0.63	Large	Large
Isazofos	69	1000	100	34	11.4	Large	Large
Chlorpyrifos	2	100000	6070	30	2.50	Small	Small
Pendimethalin	0.3	150000	5000	90	3.90	Small	Medium

*Data from SCS/ARS/CES Pesticide Properties Database (Wauchope, et al., 1992)

The thatch layer contained the greatest amount of pesticide residues throughout the research monitoring period. Thatch appeared more retentive of pendimethalin and chlorpyrifos than isazofos and metalaxyl. Twenty-eight days after application, thatch contained 21% and 14% of the pendimethalin and chlorpyrifos residue recovered. In contrast, the thatch contained less than 4% of the isazofos and metalaxyl residue recovered at the same time.

Pesticide residues were much lower in soil than in the thatch at all sampling times during the study. Metalaxyl and isazofos were more mobile than chlorpyrifos and pendimethalin. Seven days after application the top inch of soil contained 5% and 17% of the applied isazofos and metalaxyl. Metalaxyl soil residues reached a maximum (22%) at the 1" soil depth 14 days after application. Metalaxyl soil residues recovered from the 2" to 22" depths increased up to 28 days after application. Isazofos residues were lower in the Iowa soil, where more thatch was present. Less than 1% of the chlorpyrifos and pendimethalin was recovered in any soil sample down to 20" over the course of the study.

Pesticide amounts in the soil profile were highly skewed, with the exception of metalaxyl. Generally, the highest amounts of detectable pesticide were at the top 1" and the 1" to 4" soil depths during the monitoring period. The soil contained more metalaxyl than isazofos, which generally was higher than chlorpyrifos and pendimethalin. At several sampling times, metalaxyl was detected throughout the entire 2 ft depth of the soil core profile. However, metalaxyl amounts detected at the end of the 4-month monitoring period were less than 1% of that originally applied.

Based on observed disappearance rates, overall average time to 50% of the original applied pesticide degraded (DT_{50}) values were 16, 12, 10, and 7 days for metalaxyl, pendimethalin, chlorpyrifos, and isazofos, respectively, in the turf/soil profile. These pesticides appeared to degrade more rapidly in the turfgrass environment than typically reported for other agronomic cropping systems. Variability in pesticide residue amounts for each soil depth among the turf/soil core profiles indicated non-uniform dissipation in the soil.

Figure 1
Average Percent Chlorpyrifos, Isazofos, Metalaxyl, and Pendimethalin Remaining in Verdure, Thatch, and Soil of Turf/Soil Systems at Nebraska and Iowa After Application in 1991 and 1992