DEVELOPMENT of a LAYERED MODEL

to PREDICT

PESTICIDE TRANSPORT in TURFGRASS THATCH

1999 ANNUAL REPORT

presented to the

UNITED STATES GOLF ASSOCIATION

GREEN SECTION RESEARCH

Dr. Mark Carroll
Dr. Robert L. Hill
University of Maryland
Department of Natural Resource Sciences
& Landscape Architecture

Executive Summary

Objectives

1. To develop a two phase layered pesticide transport model which considers equilibrium or non-equilibrium transport within each layer and the use of appropriate pesticide adsorption coefficients for each layer.
2. To evaluate the use of the model for two of the pesticides used in the previously funded USGA study.
3. To evaluate the effectiveness of the model to predict pesticide transport in comparison to commonly used pesticide transport models such as PRZM2 or GLEAMS.

Mathematical models are often used to estimate potential pesticide transport before management strategies are implemented. Most agricultural pesticide transport models used to predict the transport of pesticides applied to turf either neglect the existence of thatch or average the carbon content of the thatch layer into the organic carbon content of the soil. Because of the high organic matter content of thatch this media has the potential to retain surface applied pesticides prior to their release to the less adsorptive soil layer. In highly porous media such as thatch, however, pesticide equilibrium is rarely achieved. Most regulatory agencies and environmental consulting firms use pesticide transport models based on linear equilibrium assumptions. Previous column studies conducted in our laboratory have shown that thatch has a significant effect on pesticide transport and that use of a two-site non-equilibrium model provides superior predictions of pesticide transport. Development of a model that considers non-equilibrium transport within thatch and soil should result in improved predictions of pesticide transport within turf. A problem with creating such a model is how to address pesticide transport in field situations where it is difficult to estimate transport parameters.

We are currently in the early stages of developing a two phase model which considers equilibrium or non-equilibrium transport within a soil containing a surface layer of thatch. An extensive examination of existing pesticide transport models has been conducted to review the various numerical techniques used to estimate pesticide transport and to determine which techniques are best suited for adoption in predicting pesticide transport in turfgrass. Although models such as the Pesticide Root Zone Model (PRZM2), the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model, and the Chemical Movement in Layered Soils (CMLS) models are commonly used by agencies such as the Environmental Protection Agency and the USDA Agricultural Research Service, these models do not consider non-equilibrium pesticide transport. Two presently available models which do consider non-equilibrium transport are the Root Zone Water Quality Model (RZWQM) and the HYDRUS model. Although these two models result in pesticide transport for non- equilibrium conditions, the numerical methods used for describing solute transport differ. While each numerical approach that one does not need to estimate the non-equilibrium field transport parameters. A disadvantage of this approach is that all soil layer thickness must be an integer number and the first horizon must be equal or greater than 2 cm in thickness. Thatch layer thickness is frequently less than 2 cm. We are presently evaluating methods by which we might modify the partial-displacement and mixing numerical techniques to more accurately address the retentive contributions of a thin thatch layer.

The HYDRUS model is a finite element model for simulating the multi-dimensional movement of water, heat, and multiple solutes in variety-saturated media. The model implements a Marquardt-Levenberg (i.e., least sum of squares) type parameter estimation procedure for inverse estimation of selected soil hydraulic and/or solute transport and reaction parameters from measured transient or steady-state flow and/or transport data. The procedure permits several unknown field parameters to be estimated from observed water contents, pressure heads, concentrations, and/or instantaneous or cumulative boundary fluxes (e.g., infiltration or outflow data). Although the numerical techniques appear attractive, the formulation of mesh grids is felt to generally be beyond the computational capabilities of most end users of the proposed model. We are studying the difficulties of porting similar numerical techniques in a one-dimensional finite difference approach.

Project Title: Development of a Layered Model to Predict Pesticide Transport in Turfgrass Thatch

Principal Investigators: Mark J. Carroll and Robert L. Hill

Project Overview- United State Golf Association funded research examining the fate of turfgrass pesticides and fertilizers has demonstrated that "current agricultural models are inadequate for predicting the fate of pesticides and fertilizers applied to turfgrasses" (USGA 1997 Call for Preproposals). Agricultural pesticide transport models do not account for the unique layered profile which exists below turfgrass foliage. Surface-applied pesticides must pass through the organically rich thatch layer present in mature turfs. Most agricultural pesticide transport models either neglect the existence of the thatch layer or average the thatch layer's carbon content into the organic carbon content of the soil profile. Studies from our previously-funded USGA project (Modeling Pesticide Transport in Turfgrass Thatch and Foliage) revealed that the organic carbon content of thatch is a less effective sorbant of pesticides than soil organic carbon, thus soil based normalized sorption coefficients reported in the literature should not be used to calculate thatch pesticide adsorption coefficients. We also found when laboratory determined thatch and soil adsorption coefficients were used to simulate pesticide transport in convective dispersion based models, only models that considered non-equilibrium transport of pesticides provided reasonable estimates of pesticide transport. The latter finding suggests that development of a model that considers non-equilibrium transport within thatch and soil should result in improved predictions of pesticide transport within turf.

Progress to Date -Initiation of this project was delayed pending the completion of our previously funded USGA project. The previously funded project was completed in mid-April of this year when Sanju Raturi, the student conducting most of research related to the project, submitted her Ph.D., dissertation to the University of Maryland Graduate School. On 1 June Dr. Sanju Raturi was hired to spearhead development the layered model outlined in the present research project. Dr. Raturi's efforts to date have focused on a comprehensive examination of the numerical techniques used in existing convective dispersion based transport models to estimate pesticide transport. At this point in time she is attempting to modify numerical techniques used within HYDRUS so that they can be incorporated into PRZM2. If she is successful our modified version of PRZM2 will have the ability to consider non-equilibrium pesticide transport. Finite element models like HYDRUS are more computationally difficult to use than finite difference models such as PRZM2. We believe far greater usage of our layered two-phase model approach will occur if we can incorporate the subroutines needed to consider non equilibrium transport within the thatch and soil layers into an existing model such as PRZM2.

Work Planned for Nov. 1 1999 - Nov. 1 2000 Period - Development of the FORTRAN code needed to simulate non-equilibrium transport within a two layer profile will likely begin in mid to late November. We anticipate that about 3 months will be required to develop a beta version of the proposed model. Testing and evaluation of the model using the pesticide transport data collected in our previously funded USGA project will require an addition 2-3 months. A working version of our Model should be available by the time of USGA's monitoring team visit in May or June of next year. By that time we will also likely have completed last of project objectives, which is compare the predicted pesticide transport of our model with widely used models such GLEAMS and the current version of PRZM2.