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Progress Report: Synthesis of Recent Turf Research and Computer Simulation Modeling - Data Evaluation, Model Calibration, Sensitivity Analysis and Predictions

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Objectives

1. Develop a questionnaire that can be administered to university researchers to help provide the site characterization data and results critical for computer modeling. (This was done in spring, 1995, and minor revisions were made this year based on our work with Dr. Smith, U.Ga.)

2. Obtain pesticide leaching and runoff data from USGA-funded researchers, and fill in data gaps where necessary.

3. Calibrate the computer simulation models PRZM and GLEAMS against the volumes of percolate water and runoff water obtained from the test plots.

4. Calibrate the models against the pesticide leachate and runoff results.

5. Evaluate the model performance in terms of validity and parameter sensitivity. Provide guidance on the use of the models for turf and the possible need for modifications of the models to make them more appropriate for turf.

Approach

We are evaluating the models against two sets of leaching data and two sets of runoff data. At completion, there should be enough information to submit a good paper to a peer-reviewed journal. As described below, we used the model PRZM2 for the first set of leaching data and GLEAMS for the first set of runoff data. However, our dialogue with the EPA has steered us toward the use of PRZM2.3 or PRZM3 for analyzing the next set of leaching and runoff data.

EPA

One benefit of this project has been the dialogue we (Mike Kenna and ETS) have developed with the EPA. We were invited to present the results of our first year's work to approximately 10 scientists from the EPA's Office of Pesticide Programs (6/14/96). There

is much interest in this topic at the EPA, and staff and management agree that more should be learned about turf so that it is not automatically lumped together with agriculture when national regulatory decisions are made.

Progress

Substantial progress was made on all five objectives in our first year, which ended May, 1996. (See our two comprehensive reports.) The progress reported below focuses on objective 2.

Update Leaching - University of Georgia

Our preliminary report showed that PRZM leachate volume predictions were only poor to fair. This may be due, in part, to the fact that we did not have soil characteristics (i.e. soil retention analyses) for the actual plots modeled. The research committee suggested that soil retention analyses be run using the actual field plots. Therefore, Al Smith agreed to run the analyses on the actual field plots. We are currently waiting for those results. PRZM will be run again when we receive the results. The new results will be compared to the previous output and our report will be updated to reflect the new data.

Leaching. All studies in the USGA's 1991-1993 research summary were reviewed to determine whether they contain usable leachate data. Three reports were selected for a closer review to see if there was enough information available to complete PRZM input parameters or if the information could be obtained from the following grantees: 1) University of Florida, 2) University of California, and 3) University of Nebraska. A dialogue was established with researchers of all three projects. The University of Nebraska (UN) project was selected for several reasons. First, it appears that all of the input parameters needed for the PRZM model can be obtained. The field study director was asked to complete a questionnaire. He was able to supply most of the information requested and noted that the rest could be obtained with further analyses of the plots. Second, the UN study was selected because it was a cool season field trial study, and a warm season field trial study was completed in the first phase of this project. Third, the turf plots were discretized into units that are compatible with PRZM input parameters. The PRZM model requires small increments for horizon evaluation (i.e., a few centimeters). Fourth, several pesticides were applied to the plots and the results show that enough residue was found in the leachate that PRZM should be able to produce comparable results as well. Fifth, the data reported were well written and the author was eager and willing to supply missing data for the model input parameters. This is probably the most important aspect of the study, reliable cooperation from the field study director. Another advantage for selecting UN is that all of the turf plots have supposedly been frozen and saved. This allows us to obtain data that we will need, if it is not already in the director's notes.

PRZM files have been set up and the parameters available from the summary reports have been recorded. A site visit is planned for November 11 & 12 to observe the turf plots and obtain data from the field study director that are not in the summary reports. Validation of all parameters will be made by the field study director to ensure accuracy. An example of data needs are as follows: hydrology parameters (i.e. pan factor, snow factor, etc.), pesticide data, irrigation rates as well as precipitation and temperature data, and soil/water retention data (i.e., field capacity, wilting point). These data should be easily obtained with collaboration of the field study director and/or analyses.

Finally, the model can be run, after obtaining all the needed input parameters from the field study director during the site visit or from followup analyses of the turf plots. At least some additional lab analyses of soil properties will be needed. Completion of the modeling runs requires that the water flux output data be calibrated with actual field results. When the water flux is calibrated appropriately the pesticide concentration output should be indicative of the actual field results. A final report will be written after the model is calibrated and validated by field results.

Runoff: Model Selection. GLEAMS. (Groundwater Loading Effects of Agricultural Management Systems) This was the model we used in the first phase of our study when we attempted to simulate the 1994 runoff research study conducted by Dr. Albert Smith, et al. at the University of Georgia. This is a popular model used by researchers and regulators. It was developed and supported by the USDA, Agricultural Research Service's Southeast Watershed Research Lab in Tifton, GA. In addition to pesticide transport and fate simulation, the GLEAMS model includes a nutrient component that predicts nitrate and phosphorus loadings in runoff and leachate. Up until now, it has been our first choice for field scale runoff modeling, for three reasons: shortcomings in the runoff component of the PRZM model's first two official releases; GLEAMS is based on the well regarded CREAMS model for pesticide runoff; and the SWAT runoff model (an upgrade of the SWRRWBWQ runoff model), with which we have extensive experience, is primarily for watershed-scale studies. The runoff component of PRZM has been improved in recent code modifications and we have been told by modelers in EPA's Environmental Fate & Ground Water Branch that GLEAMS is no longer fully supported in Tifton due to budget constraints. For these and other reasons given below, we are moving to the PRZM model for field scale computer simulation modeling of pesticide transport and fate in runoff.

PRZM. (Pesticide Root Zone Model) As noted above, we have generally avoided use of the PRZM model for runoff modeling. This was because it did not do a good job of partitioning the pesticide application in the crop and soil layers and generally overpredicted pesticide transport in runoff. Two factors have led us to give greater consideration to use of the PRZM model for simulation of turf runoff plots for this project. First, the PRZM release 2 code has recently been modified to overcome the poor performance of the model's runoff component. The unofficial version PRZM 2.3, has been distributed by

Waterborne Environmental (Reston, VA) to EPA and pesticide industry modeling groups responsible for pesticide registration activities. The changes made were to the options for describing the distribution of a pesticide throughout the crop and the soil profile. It has been well received and the changes have been incorporated by EPA's Center for Exposure Assessment Modeling in Athens, GA into the soon-to-be-available official PRZM release 3.0. Second, and possibly most important for the USGA, we have come to the understanding that the U.S. EPA will rely heavily on PRZM 2.3 and eventually PRZM 3.0 for runoff simulations. GLEAMS will not be used to the extent that it has been in the past.

Runoff: Study Site Selection. Other than the continuing work by Dr. Al Smith at the University of Georgia, there are only two turf runoff studies we are aware of that have been conducted recently by university researchers with funding support from the USGA. Dr. James Baird at Oklahoma State University is conducting an ongoing study of the impact of buffers and other management practices on pesticide and nutrient transport from turf. The study is being done on mature bermudagrass plots at the University's Turf Research Center. His longer-term goal is to eventually continue his studies on an existing golf course. Dr. Thomas Watschke at the Pennsylvania State University has participated in studies of pesticide and nutrient transport from turf with various researchers for a number of years. Dr. Doug Linde, along with Dr. Watschke and ? Borger published a paper in the Jan/Feb 1995 Green Section Record describing work done from October 1991 to October 1993. The study objective was to examine nitrate and phosphate transport in runoff and leachate samples from two different turf types. We are aware that pesticide runoff research has been done on Penn State's plots as well as the research on nutrient transport. If we are able to obtain non-USGA supported study results in addition to the USGA funded research, this could be a very important collection of data to consider for computer simulation modeling.

Oklahoma State University

Initially an appealing study:

- conducted on mature common bermudagrass turf
- managed to mimic fairway conditions
- acceptable slope range 5.4-6.6%
- 4 pesticides applied/tested - duplicate some of the U.Ga. chemicals (2,4-D, dicamba, MCPP, and chlorpyrifos)
- included nutrients
- looked at different formulations of chlorpyrifos and nutrients
- multiple management scenarios, particularly interested in variable buffer lengths.

Tom contacted Dr. James Baird at OSU on July 17, and he was very cooperative and cordial. He forwarded a manuscript submitted to JEQ, a floppy with data in spreadsheet format, and made an attempt to fill out our data questionnaire.

> The data forwarded contained much of the information we would use to develop the input parameters, however there were no site-specific soils data. This would leave a particularly significant data gap that we really could not do without. If we were to pursue this study for use in our modeling project, we would need to have Dr. Baird obtain the necessary hydrologic and physio-chemical data for each soil horizon. Further, the data would have to be collected for each of the variably managed plots.

It is a very interesting study, but unfortunately not particularly suitable for our modeling study. There were only two sampling events. These occurred during each of the two single rainfall simulations, one in July 1995 and one in August 1995. No subsequent rainfall events (natural or simulated) were sampled on days following the primary events. We should have more events and there should be several events per sampling period, particularly for a model calibration. Also, there were eight different management scenarios examined, e.g., two plots with no buffers, two plots with short buffer lengths (2.4 m) and each with a different buffer height (½" and 1½"), four plots with long buffer lengths (4.9 m) -- two of these cut to ½" height and two cut to 1½" height -- one of each height getting an aerification treatment. Although initially considered an attractive component of the study, ultimately our proposal was not structured to accommodate this number and diversity of scenarios.

Pennsylvania State University

A very promising collection of studies:

work done on turf plots from seed to maturity
two different turf types included, creeping bentgrass and perennial rye
maintained at fairway conditions
cool season turf (U. of Ga. study done on warm season turf)
single management scenario
both runoff and leachate sampled
minimum 22 events sampled
both simulated and natural rainfall events sampled
detailed data collected during simulated storm events
four pesticides considered
several days of sampling for each pesticide application
nutrients also considered, 2 nitrogen formulations & phosphorus

Stuart contacted Dr. Tom Watschke at PSU on October 31, and he is interested in cooperating; Dr. Doug Linde has moved on to Delaware Valley College - attempted to contact him on November 1 and 5, awaiting return call.

We will likely select the Penn State research for this phase of our runoff simulation project for a number of reasons. The data set is extensive, covering at least 2 years. There were at least five pesticide applications of four different pesticides and subsequently there were a minimum of 22 sampling events. Both simulated and natural rainfall events were considered. Leachate samples, in addition to runoff, were collected during the sampling events. This will likely help us to obtain a better picture of the mass balance of turf chemical fate and transport in the system. We will have an opportunity to attempt to simulate the turf crop from seeding to maturity.

We do have one major concern. Preliminary indications are that almost all of the runoff volumes were generated by "rainfall" equipment that simulated 6 in/hr of fine droplet rainfall. This does not have much relevance to typical conditions, and greatly limits the range of conditions we use for testing the model.

After we establish our dialog with Doug Linde and obtain more of the raw data for our model input and output requirements, we will evaluate the completeness of the data and take the necessary steps to fill any significant data gaps. Tom Durborow will make a site visit to Penn State to observe the turf plots and meet with the researchers resolve any outstanding uncertainties in the study's data, physical system, or management scenarios as far as it relates to the computer simulations, if we can use the study.

The model calibration will be done in two steps, as it was done for the first phase of this project. The first step will be to calibrate the hydrologic components of the model with the runoff data from the field study. The rainfall simulations were done with an irrigation rate of 6 in/hr. We will have to give some consideration to factors such as droplet size and the relationship with natural rainfall in order to obtain a proper calibration. Once we have calibrated the hydrology, then we will attempt to calibrate the pesticide component. In both steps, we will examine the parameters that most significantly impact the output (generally referred to as sensitivity analysis) and vary those values within acceptable ranges to calibrate the model. We will use statistical methods to verify the success or failure of our calibration efforts.