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Environmental Monitoring and Pest Management
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Pilot Study To Assess Spatial Variability of Soil Infiltration And Related Soil Parameters

I. Introduction

Use of simulation models to predict pesticide leaching promises great benefit because (1) vulnerable areas can be delineated on maps (2) costly field experiments can be avoided or more efficiently planned (3) new pesticides may be evaluated under a variety of circumstances on the computer (4) modified management practices can be assessed. The degree to which these features are benefits depends on the degree to which simulation models accurately portray reality.

The spatial variability of soils is one source of variation which must be considered when using pesticide leaching models to predict the downward movement of pesticides. Within a regulatory context, model predictions should be defensible for relatively large areas compared to smaller area sizes which are typically used to develop and validate leaching simulation models. Currently, PMZs are the basic unit of regulation under AB2021. These 1 square mile sections are much larger than, for example, 0.6 to 3.5 ha fields which were used to evaluate the PRZM model (Carsel et al. 1986) or data from 9 m^2 plots used to evaluate a CSMP model (Walker 1976). Even smaller scale laboratory soil columns have been employed to collect data for validation of models (Hetrick et al. 1988, Melancon et al. 1986). The progressive validation of models from laboratory column experiments to field or larger scale experiments requires an effort at scaling the uncertainty associated with soil spatial variability; otherwise, leaching estimates from a model based on small scale validation may underestimate variability in leaching estimates for larger scale areas such as sections or townships. Thus large scale variability is directly relevant to the eventual use of simulation modeling in developing regulatory stategy.

II. Objectives

This initial study constitutes a pilot study for a larger project aimed at examining the scaled variability relationships from a few meters up to a 1/4 to 1 square mile area. The techniques of infiltration sampling and CEC estimation are new to the field group, as well as the statistical techniques for analyzing spatial data are new to the research and technical group. Therefore an overall objective of the study is to gain experience with the field and statistical techniques associated with these procedures.

Specific objectives are to (1) quantify the distribution of infiltration rates, pH, cation exchange capacity (CEC), organic carbon, texture, bulk density at 2 spatial scales (2) examine the frequency distributions of infiltration rates (3) to compare the distributions at the small to the large scale (4) to perform multivariate analysis on the measured soil parameters in order to understand how soil parameters vary together (5) to compare the infiltration rates at the surface to infiltration rates below the surface (6) to perform a geostatistical analysis of the spatial data for each soil parameter to compare the semivariograms and spatial correlation.

III. Personnel

This project will be conducted by the Environmental Hazards Assessment Program. John Sanders will be the overall supervisor. Other key personnel include:

Project leader - Bruce Johnson
Senior Staff Scientist - John Troiano
Study Design/Data Analysis - Bruce Johnson
Field Sampling - John Sitts

IV. Study Plan/Experimental Design

Two 125m x 125m fields with the same, relatively homogeneous soil type will be located. Using a 12.5 m buffer around the edge, a 5 x 5 grid will be established (25 m spacing) within each field. At each grid node, surface infiltration and subsurface infiltration (50 cm) will be measured utilizing a 'Guelph Permeameter' (Reynolds and Elrick 1985). Soil samples will be taken for laboratory analysis at each depth to determine soil moisture content, pH, bulk density, organic carbon, CEC and texture. A random 25m x 25m sub-square will be selected in each field. Using a 2.5 m buffer strip, a 5 x 5 grid will be established (5 m spacing) and the same measurements as in the large grids will be taken.

A conventional ANOVA will be utilized for each parameter with 2 replications, scale and depth as the treatment variables.

Source	df
Reps (R)	1
Scale(S)	1
Error(R x S)	1
Depth (D)	1
S x D	1
Subplot Error (R x S x D)	1
Sub-Subplot error	93

The preceding analysis will be of some interest for comparison of the error to the subplot error. Because of very low degrees of freedom, it is not expected to find significant differences. However, the distributions of measurements for each parameter will be more important. Kolmogorov-Smirnov statistic will be applied to compare the distributions at 2 scales (Sokal and Rohlf 1981). The distributions will be fit with the lognormal distribution, then ANOVA applied to the fitted statistics (mean and standard deviation) using the same design as above, without the subplot error. For example, the standard deviation can be analyzed with the above design. The estimate of error will provide information for estimating sample size for the larger project.

A second form of analysis will be to assess the multivariate relationships implicit in the data set. For example, known correlations exist between texture, bulk density and infiltration rate (Carsel and Parrish 1988, Rawls and Brankensiek 1985, Cosby et al. 1984). The results of this analysis may be utilized to simulate 'random' soils which embody the same implicit multivariate statistical characteristics as contained in the data (Carsel and Parrish 1988). The importance of these characterizations is to excite simulation models using realistic soil characteristics which vary in a realistic way.

Finally, the third analytical approach will utilize geostatistical methodology to construct semi-variograms for each soil parameter (infiltration, soil moisture content, texture, bulk density, CEC, pH, organic carbon). A semi-variogram can be constructed by determining the following function:

$$V(s) = E(I(X+s)-I(X))^2/2$$

where V is the semivariogram function of s, s is the distance from the point X (a point on the 2 dimension grid), I is the function of X which is the infiltration rate at X, and E is the expected value (Gutjahr 1985).

A plot of the function, V(s), indicates how values are correlated over space. In theory, in a random environment, as values are farther apart, they become less correlated until a maximum degree of uncorrelation is achieved. In practice, particularly, in agricultural fields subjected to linear smoothing and ploughing operations, correlations may occur at regular intervals. By taking grids at 2 spatial scales, the semivariogram will be extended farther than normal transect or grid type studies in which sampling intensity over the entire grid would make such extensions impractical. Moreover, by replicating, some measure of uncertainty in the semi-variogram itself can be estimated by taking the mean over replications of the constructed semi-variograms.

V. Sampling Methods

Conventional soil sampling techniques will be used for soil moisture percent, pH, bulk density, organic carbon, CEC. Infiltration measurements will be taken using the 'Guelph' permeameter (Soilmoisture Equip. Corporation 1986). A total of 100 samples will be collected (2 depths x 2 ~~reps~~ fields x 25 samples/depth-rep). Sampling for percent moisture will require sealed soil containers. Sampling for bulk density will require auguring to extract a known volume of soil. x 2 grid sizes

VI. Chemistry Methods/Quality Control

VII. Timetable

Sampling will occur in June-July, 1989.

Data analysis will occur August-September, 1989.

Final report write up and recommendations for subsequent study, December 1989.

VIII. References

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