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Evaluation of Current Simulation Models to Predict Pesticide Movement to Ground and Surface Water Under California Conditions

STUDY #I77

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I. INTRODUCTION

Environmental fate and transport assessments are an integral part of the pesticide registration process. These assessments include an evaluation of the pesticide's potential to impact ground or surface waters using data from field studies. While properly designed field experiments provide a relatively high degree of confidence in predicting pesticide fate under particular experimental conditions, extrapolation of experimental data to other locations or cropping scenarios is often impossible. Field studies are also costly and resource intensive, so that it is impractical to conduct studies over the entire range of conditions where pesticide use might occur. As a result, there has been increasing interest on the part of both the pesticide industry and federal regulators in the use of computer simulation models to predict pesticide fate under different conditions.

In 1993, the U.S. Environmental Protection Agency, Office of Pesticide Programs and the American Crop Protection Association established the FIFRA (The Federal Insecticide, Fungicide and Rodenticide Act) Exposure Modeling Working Group (EMWG). Their purpose was to evaluate the use of simulation models for predicting environmental exposure to pesticide residues in ground and surface water. The EMWG has agreed on a list of recommended models for simulating pesticide runoff and leaching (FIFRA Exposure Modeling Working Group, 1995). The two recommended primary runoff and leaching models are GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) and PRZM (Pesticide Root Zone Model).

More recently, USEPA's implementation of the Food Quality Protection Act of 1996 (FQPA) has led to a pressing need to quantitatively predict ranges and magnitudes of expected environmental pesticide concentrations in ground and surface waters. The FQPA mandates that USEPA reevaluate all current tolerances and review all current pesticide registrations using new health-based safety standards. These standards require USEPA to consider the contribution of all non-occupational sources of exposure - including drinking water - during the risk assessment process. USEPA also uses this "aggregate exposure" approach in evaluating section 18 requests. Simulation modeling plays an integral part in USEPA 's exposure assessments (USEPA, OPP, HED, 1997); four models are currently used to evaluate expected environmental pesticide concentrations in ground and surface water: SCI-GROW, GENEEC (GENeric Environmental Expected Concentrations), and the linked models PRZM/EXAMS (EXAMS: Exposure Analysis Modeling System). SCI-GROW and GENEEC are crude "screening-level" models used to identify those pesticides which, by virtue of their properties, are not expected to reach ground or surface water in significant concentrations (FIFRA SAP, December 1997).

Many of these models have been developed or validated using field data from the mid-western or southern United Sates. Due to California's unique climatic characteristics and widespread use of irrigation, the applicability of the foregoing models for predicting pesticide fate and transport under California conditions is questionable. For instance, both GLEAMS and PRZM utilize a crude "tipping-bucket" approach to describing water movement downward through the soil; neither model allows for upward water movement due to evaporation. Such movement might be an important factor in pesticide transport under arid irrigated conditions. In contrast, other simulation models (e.g., LEACHM - Leaching Estimation And Chemistry Model) utilize more sophisticated algorithms to describe water movement. The advantage of more sophisticated modeling approaches for describing movement under arid irrigated conditions may be outweighed by more intensive input data requirements.

In summary, the popularity of pesticide fate and transport simulation modeling is increasing among both federal regulators and the pesticide industry. Several models have been developed and are currently being used at the federal level to evaluate experimental field data and to predict ambient environmental concentrations; regulatory decisions are now based in part on modeling results. This study will improve DPR's ability to address proposed federal regulatory decisions that are based on simulation modeling, and to critically evaluate registrant data submissions that utilize simulation modeling.

II. OBJECTIVE

The objective of this study is to evaluate the usefulness of various simulation models for predicting pesticide transport to ground and surface waters under California irrigated conditions. This evaluation will include:

* quantitative comparisons between model output and measured environmental data,
* qualitative comparisons of model operations and quality of supporting documentation,
* data input requirements for the models, and
* sources and availability of input data required.

III. PERSONNEL

This study will be conducted by the Environmental Hazards Assessment Program (EHAP) under the general direction of Don Weaver, Senior Environmental Research Scientist (supervisor). Key personnel are listed below:

Project Leader:	Frank Spurlock
Senior Staff Scientist:	Bruce Johnson

Questions concerning this study should be directed to Mark Pepple at (916) 324-4086, facsimile (916) 324-4088.

IV. STUDY DESIGN

MODELS

PRZM v. 3.12 beta - March 1998
  Includes EXAMS II and VADOFT extensions
SCI-GROW v. 1 .O December 1997
GENEEC v. 1.2 February 1998
GLEAMS v. 2.10 November 1993
LEACHM v. September 1992

GENERAL SCENARIOS

Vadose zone models - soil concentrations

Approach: compare model output from the vadose zone models PRZM, PRZM/VADOFT, GLEAMS, and LEACHM to short-term (6 week) field solute concentration vs depth experimental data from a bromide/atrazine leaching experiment.

Troiano et al. (1990) evaluated the effect of irrigation method and level of water application on downward movement of atrazine, chloride, and bromide tracers in a coarse Fresno soil. Model predictions will be compared to the concentration vs depth field data from all 3 levels of the sprinkler and basin irrigations. The bromide tracer data will be used to calibrate soil hydraulic parameters of the models; model-to-field comparisons will be made using atrazine and chloride concentration vs depth data. Variables to be compared may include: solute mass recovered in root zone, total solute mass remaining in the 10 foot profile, and depth to 50% applied mass recovery.

Vadose zone models - pesticide flux to ground water

Approach: Compare flux predictions from the vadose zone models PRZM, PRZM/VADOFT, SCI-GROW, GLEAMS, and LEACHM to the concentration distribution of pesticide detections in wells in a large coarse-textured soil area of Fresno County.

Realistic estimates of annual recharge in the Fresno area will be developed using data from recent chlorofluorocarbon age-dating studies in California (Spurlock, 1997; Dubrovsky et al., 1998) and other sources (Department of Water Resources, 1993; Hanson, B., 1994, Snyder et al., 1986). Using net annual downward water and model-predicted pesticide fluxes, model-based estimates of ground water herbicide concentrations will be developed and compared to the concentration distribution of simazine and diuron detections in coarse soil areas of Fresno County.

Surface water *runoff models* -
Approach: Compare PRZM/EXAMS, GLEAMS, and GENEEC predicted runoff concentrations to (a) the distribution of edge-of-field water concentrations of herbicides and dormant spray insecticides, and (b) ambient surface water concentrations of herbicides and dormant spray insecticides.

Output from the surface water models will be compared with the concentration distribution of (1) edge-of-field water samples from preemergent herbicide and dormant spray runoff field experiments (Spurlock et al., 1997; Troiano and Garretson, 1998; Ross et al., 1997) and with the concentration distribution of ambient detections from DPR's surface water database.

INPUT DATA
Daily weather data - California Irrigation Management Information Service (CIMIS) weather stations in the Fresno area.
Soil texture data - previous EHAP studies, soil surveys.
Soil hydraulic characteristics - various sources to be investigated during model calibration phases: soil surveys, model documentation, UNSODA database, various regression-based pedotransfer functions.
Pesticide physicochemical/degradation data - EHAP Pestchem database, USDA Agricultural Research Database, open scientific literature.

TIMETABLE
Nov 98 - Jan 99. Obtain and install models, run test input files, research and obtain input data, calibrate models.

Feb 99 - April 99. Run models under various scenarios and analyze data.

May 99 - December 99. Continue data anlysis, report preparation.

V. DATA ANALYSIS

Concentration vs. depth data will be analyzed graphically and compared using different criteria/test statistics available in the literature but not yet selected (e.g., Parrish and Smith, 1990; Loague and Green, 1991). Direct comparison of model predicted and ground, surface, and edge-of-field concentrations will be done by evaluating the distribution of the measured data, determining the percentile value of the model prediction and summarizing the information graphically.

VI. LITERATURE CITED

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