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Project Summary

Ecosystem Responses to Alternative Pesticides in the Terrestrial Environment

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A conceptual model was developed to describe aspects of the fate and effects of a pesticide in an orchard ecosystem. In order to refine, parameterize, and test a mathematical model based upon this conceptual model, a program of field and laboratory experiments was undertaken. The environmental behavior of azinphosmethyl was studied in a Michigan apple orchard watershed to gather data for the model on initial distribution within the orchard, vertical movement of the pesticide under the influence of rainfall, loss from the orchard with runoff, and the effects of the pesticide on several invertebrate populations. The estimated proportion of a low-volume application initially distributed within the orchard averaged .624 (standard deviation of .149) over three seasons (1976-1978). Examination of residues reaching each layer showed the majority of the dislodgeable residues were distributed to the trees and grass-broadleaves. The litter-moss and soil contained residue levels roughly ten times lower than tree leaf residues. Runoff studies indicated loss, via this route, of less than 1% azinphosmethyl residues present in the orchard. The generalized model developed, entitled the Pesticide Orchard Ecosystem Model (POEM), includes as a special case the model for the azinphosmethyl applications under the conditions of this field study. POEM also includes facilities for altering parameters to describe effects of other formulations, other pesticides, other application procedures and/or other field conditions.

This Project Summary was developed by EPA's Environmental Research Laboratory, Corvallis, OR, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The work presented in the full report is one portion of an effort to characterize the dynamics and effects of an example compound in the terrestrial environment, utilizing primarily field measurements and the methodology of systems modeling and simulation. Data collection, model refinement, and revised experimental design were done iteratively, yielding a model that is parameterizable and data that are relevant to the problem being attacked.

The study of pesticide dynamics through *in situ* field studies is difficult due to the lack of natural or planned experiments (inability to control much of the variance, i.e., climatic conditions) and the relatively high levels of error associated with field data. Modeling techniques were employed to aid in the understanding of the necessarily large amount of field data needed to construct a "meaningful" picture of the pesticide's fate.

Description

The field experimental program used to investigate the distribution, attenuation and movement of the organophosphate insecticide azinphosmethyl, 0,0-dimethyl-5-(4-oxo-1,2,3, benzotriazin-3(4H)-ylmethyl) phosphorodithioate (Guthion[R]), in a Michigan apple orchard is given in Chapter I. The compound was followed from its spray application through the orchard vegetation/litter/soil environment and into aquatic systems. The form of the model describing azinphosmethyl movement and attenuation, as well as data handling procedures and the derived rates, is presented in Chapter II. Observations were made concurrently within the same orchard to examine the effects of azinphosmethyl on several ground-dwelling invertebrates, including detailed studies of the isopod *Trachelipus rathkei*. Field and laboratory data collected on *T. rathkei* were used to develop a model describing its ecobiology and temporally-distributed pesticide-induced mortality. The output of the fate model described in Chapter II was used to determine the time-course of azinphosmethyl exposure.

In Chapter III the field experimental program used to determine azinphosmethyl airborne residues is presented. A multi-component kinetic model used in the assessment of the contribution of airborne loss to the overall attenuation of deposit residues is also described.

In Chapter IV, movement and attenuation of azinphosmethyl are examined as a function of environmental conditions. A computer simulation is described which allows the user to predict the fate and effects of azinphosmethyl on several types of organisms.

Chapter V describes the results of the field sampling program for invertebrates in the orchard plots, providing information on the effects of azinphosmethyl spraying (additional material on the isopod *T. rathkei* is found in Chapter IX). Chapter VI contains the results of a laboratory assessment of the toxicity of azinphosmethyl and diazinon to various invertebrates. Chapter VII briefly describes the models developed for spiders, earthworms, and springtails. Chapter VIII presents a detailed description of the ecobiology of the isopod *Trachelipus rathkei*, while Chapter IX describes the effects of the azinphosmethyl spray program on the *T. rathkei* field population. Chapter X presents the model for *T. rathkei*, including both its general life cycle and its response to pesticide exposure.

Appendix A documents the data analysis procedures employed locally at Michigan State University to parameterize the model. Appendix B is the users' guide for the Pesticide Orchard Ecosystem Model (POEM) described in this report.

Recommendations

(1) Further work to refine, parameterize, and test the components of the POEM model, or similar models, for other pesticides and other conditions should be undertaken. In many cases, the current forms are derived based on sparse data in the literature. While predictions based on these forms may be informative and useful in some contexts, they are not likely to be very accurate for predicting actual fate and impacts of pesticides until they have been carefully refined based on currently non-existent data. Nevertheless, the present model may be helpful, because it allows the user to determine the implications of various sets of assumptions about pesticide dynamics and effects.

(2) Work on models for the long-term effects of pesticide exposure on populations of invertebrates should be continued. While this study includes a reasonable model for effects of azinphosmethyl on isopods and less refined models for collembola, earthworms, and spiders, the methodology should be extended and refined through application to other pesticides and organisms.

(3) The model presented here does not provide an overall indicator of the ecosystem-level impact of a pesticide in a particular situation. While impacts on individual populations are likely to be key components of any sound measure of overall impact, the importance and role of each population in the ecosystem must also be defined and incorporated in the measure. Research aimed at identifying key populations and modeling their functions should be undertaken. The search for integrating measures or indicators of ecosystem stress or damage for terrestrial systems should be broadened and intensified.

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***Jay D. Gile** is the EPA Project Officer (see below).*
The complete report consists of two parts, entitled "Ecosystem Responses to Alternative Pesticides in the Terrestrial Environment:"
"A System Approach," (Order No. PB 84-162 726; Cost: $25.00)
"POEM Source Program, Sample Data, Sample Runs (Magnetic Tape," (Order No. PB 84-162 734; Cost: $790.00)
The above report and magnetic tape will be available only from: (cost subject to change)
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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