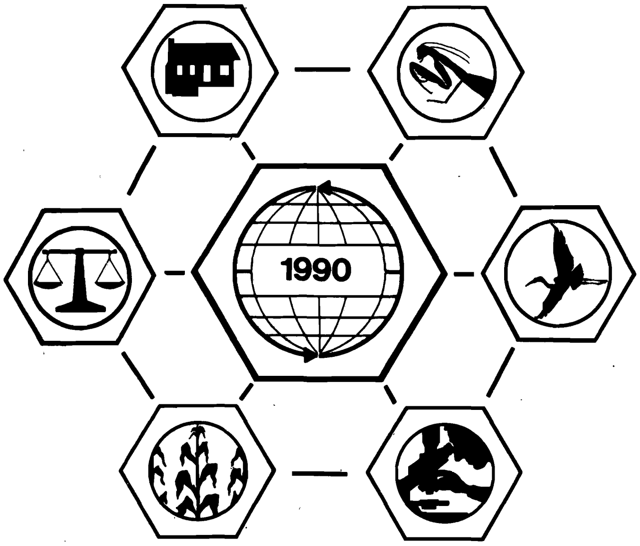
Pesticides in the Next Decade: The Challenges Ahead

Third National Research Conference

November 8-9, 1990



Program and Presenters' Abstracts

Virginia Water Resources Research Center
Virginia Polytechnic Institute and State University

Third National Research Conference

Pesticides in the Next Decade: The Challenges Ahead

November 8-9, 1990
Hyatt Richmond at Brookfield, Virginia

Sponsored by
Virginia Water Resources Research Center
Virginia Polytechnic Institute and State University

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Virginia Water Control Board
Water Pollution Control Federation
Wildlife Management Institute

This publication and several of the research projects summarized in it were financed in part by the U.S. Geological Survey, Department of the Interior, as authorized by the Water Resources Research Act of 1984.

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A publication of the Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University. William R. Walker, Director; Diana L. Weigmann, Assistant Director for Research and Administration

Table of Contents

Foreword

Across the nation, public dialogues on pesticide issues increasingly are becoming polarized. The communication and exchange of statistically valid research data are essential to reach a broad consensus among groups and individuals with diverse, firmly held opinions on pesticide use.

In June of 1988 the Virginia Water Resources Research Center sponsored and published the proceedings of a national symposium, **Pesticides: Risks, Management, Alternatives.** Stimulated by the response of participants and the intense interest in pesticide issues in Virginia and nationwide, in 1989 the Virginia Water Resources Research Center organized the second national research conference, **Pesticides in Terrestrial and Aquatic Environments.**

At this conference and in the 555-page proceedings, researchers from 23 states, the District of Columbia, and Canada presented information on a wide range of topics—environmental effects of pesticide use; pesticides in water supplies and wastewater sludge; pesticide waste disposal; case studies of pesticide pollution; pesticide monitoring in groundwater, surface water, and terrestrial environments; risk assessment; environmental regulations; management techniques for nonpoint surface pollution control; and cost-benefit analyses of water quality impacts. We surveyed participants of the 1989 conference to gauge the interest level and need for a third conference on pesticides. The response was overwhelmingly positive, and this year's conference **Pesticides in the Next Decade: The Challenges Ahead** has 19 cosponsoring organizations and 67 presenters from a number of different states and a variety of universities, agencies, businesses and other organizations. An even wider array of pesticide topics will be covered by presenters at the 1990 National Pesticide conference and published in the accompanying proceedings.

The balancing of risks, benefits, and responsibilities to ensure breathable air, drinkable water, the survival of diverse wildlife species, parks, wilderness, industrial and agricultural growth, and a high quality of life for future generations requires an integrated, multidisciplinary approach. One of the objectives in continuing to sponsor these national symposia and publishing their proceedings is to stimulate multidisciplinary and interdisciplinary research, analyses, and discussions of pesticide issues nationwide. In addition to identifying information gaps and research needs for future investigations, **Pesticides in the Next Decade: The Challenges Ahead** and its proceedings should facilitate the synthesis and interpretation of scientific data by policymakers, researchers, scientists, manufacturers, and public interest groups and promote improved communications and the resolution of pesticide issues.

William R. Walker, Director
Diana L. Weigmann, Assistant Director
Virginia Water Resources Research Center

Program

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NATIONAL RESEARCH CONFERENCE - NOVEMBER 8-9, RICHMOND

CONFERENCE DIRECTOR

- **Dr. Diana L. Weigmann**, Assistant Director of Research and Administration, Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg

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- Bruce A. Julian, U.S.D.A. Soil Conservation Service, Richmond
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- Harry H. Gregori, Jr., Director, Office of Policy and Planning, Virginia Department of Waste Management, Richmond
- Dr. R. Gene Gilbert, National Agricultural Chemical Specialist, Ecological Sciences Division, Soil Conservation Service, Washington, D.C.
- George H. Gilliam, Chairman, Department of Agriculture and Consumer Services, Pesticide Control Board, Richmond
- Jim Cox, Chief Engineer, Department of Conservation and Recreation, Division of Soil and Water Conservation, Richmond
- Bob Duncan, Virginia Department of Game and Inland Fisheries, Richmond
- Charles F. Finley, Jr., Executive Vice President, Virginia Forestry Association, Richmond
- Dr. Michael Weaver, Coordinator, Chemical, Drug and Pesticide Unit, Virginia Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg

PESTICIDES IN THE NEXT DECADE: THE CHALLENGES AHEAD

CONFERENCE SCHEDULE

Wednesday, November 7

Registration for Conference	7:30-9 p.m.	

Thursday, November 8

Registration	7:30-8:30 a.m.	
Welcome	8:30-8:55 a.m.	Marvin A. Lawson Program Manager Office of Pesticide Management Department of Agriculture and Consumer Services, Richmond
Keynote Address	8:55-9:40 a.m.	Richard Wilson Mallimckrodt Professor of Physics Harvard University, Cambridge
Coffee Break	9:40-10 a.m.	
Session A	10 a.m.-12:05 p.m.	
Session B	10 a.m.-12:05 p.m.	
Lunch and Speaker	12:15-1:45 p.m.	Yacov Y. Haimes Lawrence R. Quarles Professor of Systems Engineering and Civil Engineering and Center Director, University of Virginia, Charlottesville
Session C	2-3:40 p.m.	
Session D	2-3:40 p.m.	
Coffee Break	3:40-4:10 p.m.	
Session E	4:10-5:25 p.m.	
Session F	4:10-5:25 p.m.	
Reception	6-8:00 p.m.	

NATIONAL RESEARCH CONFERENCE - NOVEMBER 8-9, RICHMOND

Friday, November 9

Session G	8-10:05 a.m.
Session H	8-10:05 a.m.
Session I	8-10:05 a.m.
Coffee Break	10:05-10:30 a.m.
Session J	10:30-12:10 p.m.
Session K	10:30-12:10 p.m.
Session L	10:30-12:10 p.m.
Lunch	12:15-1:45 p.m.
Session M	2-4:30 p.m.
Session N	2-4:05 p.m.
Session 0	2-4:05 p.m.

Session A -- Pesticides in Drinking Water Supplies

Moderator: John Johnson, Assistant Director of Public Affairs, Virginia Farm Bureau, Richmond

Herbicide Concentrations in Ohio's Drinking Water Supplies: A Quantitative Exposure Assessment
D.B. Baker*, Water Quality Laboratory, Heidelberg College, Tiffin, Ohio

Implementation of the National Survey of Pesticides in Drinking Water Wells
J.J. Boland*, National Pesticide Survey, U.S. EPA, Washington, D.C.

The Effects of Reporting Limits on Characterization of Presence of Pesticides and Nitrates in Groundwater
J. Briskin*, National Pesticide Survey, U.S. EPA, Washington, D.C.; D. Munch, U.S. EPA, Cincinnati, Ohio; R. Maxey, U.S. EPA, Bay Saint Louis, Mississippi

Results of the National Survey of Pesticides and Nitrates in Drinking Water Wells
J. Briskin* and J. Boland, National Pesticide Survey, U.S. EPA, Washington, D.C.

Herbicides in Surface and Ground Water of Agricultural, Carbonate Valleys, Lancaster County, Pennsylvania
D.W. Hall* and P.L. Lietman, U.S. Geological Survey, Harrisburg, Pennsylvania

Session B -- Policy and Decision-Making

Moderator: Jim Cox, Chief Engineer, Department of Conservation and Recreation, Division of Soil and Water Conservation, Richmond

Adoption of Alternative Management Systems to Improve Water Quality Under Uncertainty
P. Setia and D. Letson*, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Tipping the Scales: The Benefit Side of the Pesticide Risk-Benefit Balance
T. Shistar, National Coalition Against the Misuse of Pesticides, Lawrence, Kansas; S. Cooper*, National Coalition Against the Misuse of Pesticides, Washington, D.C.

A Decision-Making Framework for the Development of Agricultural Chemical Management Plans
E.P. Ditschman*, Institute of Water Research, Michigan State University, East Lansing; J.R. Black and J.P. Hoehn, Agricultural Economics, Michigan State University, East Lansing

Farmers' Reactions to Proposed Public Policies for Reducing the Risk of Water Contamination from Agricultural Pesticides
J.D. Esseks*, Center for Governmental Studies, Northern Illinois University, De Kalb;
D.R. Dyer, American Farmland Trust, Washington, D.C.; S.E. Kraft, Department of Agribusiness Economics, Southern Illinois University, Carbondale

Setting a Place at the Table: Creating a Role for Agricultural Producers in Environmental Regulation
L. Elworth*, Pennsylvania Apple Marketing Program, Harrisburg, Pennsylvania

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*Presenter

Session C -- Pesticide Removal and Disposal

Moderator: S. Mason Carbaugh, Commissioner, Virginia Department of Agriculture and Consumer Services, Richmond

Removal of Pesticides from Contaminated Groundwater by Reverse Osmosis
A.M. Dietrich*, Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg; S.B. Chong, Los Angeles Water Authority, Azusa, California; M.A. Robinson, Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg; D.D. Ludwig, Engineering Fundamentals, Virginia Polytechnic Institute and State University, Blacksburg; J. Sherrard, Civil Engineering, Mississippi State University, Mississippi State

Studies on Demulsification and Sorption of Several Pesticides onto Lignocellulosic Substrates using Fluorometric and Gas Chromatographic Techniques
D.N. Judge* and D.E. Mullins, Department of Entomology, G.H. Hetzel, Department of Agricultural Engineering, and R.W. Young, Department of Biochemistry and Nutrition, Virginia Polytechnic Institute and State University, Blacksburg

Treatability of Pesticide Active Ingredients by Hydrolysis: Bench-Scale Treatability Study
D.A. Gardner*, Radian Corporation, Milwaukee, Wisconsin; E.A. Bicknell and J.R. Zimmerman, Radian Corporation, Herndon, Virginia

Treatability of Pesticide Active Ingredients by Membrane Filtration: Bench-Scale Treatability Study
G.L. Huibregste, Radian Corporation, Milwaukee, Wisconsin; E.A. Bicknell* and J.R. Zimmerman, Radian Corporation, Herndon, Virginia

Session D -- Testing and Monitoring

Moderator: Edward E. LeFebvre, Director, Bureau of Chemistry, Division of Consolidated Laboratory Services, Virginia Department of General Services, Richmond

Synthetic Resins as Monitoring Tools
T. Shearer* and J.W. Bishop, Department of Biology, University of Richmond, Richmond, Virginia

Evaluation of the Role of Diazinon in the Toxicity of a Municipal Wastewater Treatment Plant Effluent
J.A. Botts* and L. Fillmore, Engineering-Science, Inc., Fairfax, Virginia; E. Durhan, U.S. EPA, Environmental Research Laboratory, Duluth, Minnesota; T. Pereira, Public Works Commission, Fayetteville, North Carolina; D.F. Bishop, U.S. EPA, Risk Reduction Research Laboratory, Cincinnati, Ohio

Comparative Toxicokinetics of Carbaryl Using a Sensitive HPLC Method
M. Ehrich*, J. Wilcke, L. Correll, J. Strait, G. Thornwall, and W. McCain, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Polytechnic Institute and State University, Blacksburg

Quantification of Chlorinated Hydrocarbon Pesticides in Biological Specimens: Plasma, Fat, and Stool
J.J. Saady* and A. Poklis, Department of Pathology, Medical College of Virginia, Virginia Commonwealth University, Richmond

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*Presenter

Session E -- Pesticide Degradation in Soils

Moderator: Joel Artman, Chief, Pest Management, Virginia Department of Forestry, Charlottesville

Pesticide Leaching and Persistence in a Coastal Plain Soil in Virginia
C.D. Heatwole*, S. Mostaghimi, T.A. Dillaha, Department of Agricultural Engineering, and R.W. Young, Department of Biochemistry and Nutrition, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Herbicide Sorption and Mobility in Delaware Soils
R.M Johnson* and J.T. Sims, Department of Plant and Soil Science, University of Delaware, Newark

Effects of Mineral and Soil Surfaces on the Chemical Degradation of Atrazine: A Critical Review
J. Schmidt*, Analytical Bio-Chemistry Laboratories, Inc., Columbia, Missouri

Session F -- Analytical Procedures and Assays

Moderator: David D. Effert, Technical Services Chief, Division of Sanitarian Services, Virginia Department of Health, Richmond

Quantitative Enzyme Immunoassays of Pesticides in Water, Soil, and Foods at Part Per Billion Levels
R.O. Harrison* and B.S. Ferguson, ImmunoSystems, Inc., Scarborough, Maine

A New Method for Detecting Genotoxic Chemicals in Water or in Environmental Samples
K. Schurr* and H. Xu, Department of Biological Sciences, Bowling Green State University, Bowling Green, Ohio

New, Rapid Gas Chromatographic/Mass Spectrometric Analytical Procedure for Insect Growth Regulator Diflubenzuron
M.J. Wimmer*, Department of Biochemistry, West Virginia University Health Sciences Center, Morgantown; R.R. Smith, Department of Biochemistry, Mass Spectrometry Center, West Virginia University, Morgantown; J.J. Jones, Department of Pharmacology, University of Rochester Medical Center, Rochester, New York

Session G -- Economic and Environmental Tradeoffs

Moderator: George Gilliam, Chairman, Department of Agriculture and Consumer Services, Pesticide Control Board, Richmond

An Integrated Model of Agricultural Production and Water Quality: Application to Pesticides, Surface Water, and Ground Water
S.R. Crutchfield* and R.J. Brazee, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Economic and Environmental Implications of Planting Herbicide Resistant Corn in Iowa
S.K. Kaaria*, L.C. Thompson, and M.L. Hayenga Department of Economics, Iowa State University, Ames

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*Presenter

Examining the Trade-off Due to Policies Regulating Agrichemical Use: An Application to U.S. Agriculture
P.G. Lakshminarayan*, J.D. Atwood, L.C. Thompson, J. Shogren, and S.R. Johnson, Department of Economics, Center for Agricultural and Rural Development, Iowa State University, Ames; J.A. Maetzold, USDA, Soil Conservation Service, Washington, D.C.

Environmental and Productivity Impacts of Pesticide Practices: EPIC-PST Simulation
G.J. Sabbagh, Department of Agricultural Engineering, P.E. Norris*, Department of Agricultural Economics, S. Geleta, Department of Agronomy, D.J. Bernardo, Department of Agricultural Economics, R.L. Elliott, Department of Agricultural Engineering, H.P. Mapp, Department of Agricultural Economics, and J.F. Stone, Department of Agronomy, Oklahoma State University, Stillwater

Effects of Agricultural Pesticides' Use Restrictions in the United States
P. Setia* and K.A. Algozin, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Session H -- Environmental Assessments and Wildlife

Moderator: Bruce Julian, State Resource Conservationist, U.S.D.A. Soil Conservation Service, Richmond

A Test of Avoidance of Herbicides and Changes in Kidney and Liver Weights in *Peromyscus leucopus*
J.P. Sullivan*, Department of Fisheries and Wildlife Science, Virginia Polytechnic Institute and State University, Blacksburg; E.R. Stinson, Virginia Department of Game and Inland Fisheries, Blacksburg; P.F. Scanlon, Department of Fisheries and Wildlife Science, Virginia Polytechnic Institute and State University

Assessment of a New Jersey Lake Contaminated with Fenamiphos
L.W. Meyer* and D. Russell, Pesticide Control Program, New Jersey Department of Environmental Protection; J.B. Louis, L. Jowa, G. Post, and P. Sanders, Division of Science and Research, New Jersey Department of Environmental Protection, Trenton

Pesticide-Related Wildlife Mortality in Virginia, 1980 - 1990
E.R. Stinson*, Virginia Department of Game and Inland Fisheries, Blacksburg

DDT and Its Metabolites' Residues and Persistence in California Wetlands and Their Effects on Migratory Bird Management in the Pacific Flyway
J.C. Wolfe*, U.S. Fish and Wildlife Service, Portland, Oregon; S. Goodbred, U.S. Fish and Wildlife Service, Laguna Nigel, California; W. Henry, U.S. Fish and Wildlife Service, Fallon, Nevada

The Potential Threat of Pesticides on the Lake Kinneret (Israel) Ecosystem
D. Wynne*, Israel Oceanographic & Limnological Research Co., The Yigal Alon Kinneret Limnological Laboratory, Tiberias, Israel

Session I -- Risk Analysis and Strategies for Predicting and Reducing Pesticides in Ground and Surface Water

Moderator: R. Gene Gilbert, National Agricultural Chemical Specialist, Ecological Sciences Division, Soil Conservation Services, Washington, D.C.

Interpretation of Atrazine in Ground Water Data Using a Geographic Information System
K. Balu*, CIBA - GEIGY Corporation, Greensboro, North Carolina; R.T. Paulsen, The Paulsen Group, Northport, New York

*Presenter

Reduced Herbicide Application Strategies to Minimize Groundwater Contamination in Sandy, Coarse-Textured Soils
T.J. Bicki*, Department of Agronomy, L.M. Wax, USDA-ARS, and S.K. Sipp, Department of Agronomy, University of Illinois, Urbana

The SCS/ARS/CES Pesticide Properties Database: Combining it with Soils Property Data for First-Tier Comparative Water Pollution Risk Analysis
D.W. Goss*, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Texas; A.G. Hornsby, IFAS, University of Florida CES, Gainesville; R.D. Wauchope, Agricultural Research Service, U.S. Department of Agriculture, Tifton, Georgia

The SCS/ARS/CES Pesticide Properties Database: A Set of Values for First-Tier Comparative Water Pollution Risk Analysis
R.D. Wauchope*, Agricultural Research Service, U.S. Department of Agriculture, Tifton, Georgia; A.G. Hornsby, IFAS, University of Florida CES, Gainesville; D.W. Goss, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Texas; J.P. Burt, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Application of Risk Screening Techniques to Twelve Pesticides Used in Maryland
R.B. Kroll*, D.L. Murphy, and M.J. Garreis, Maryland Department of the Environment, Water Management Administration, Baltimore

Session J -- Resistance, Residues, and Remediation

Moderator: Elizabeth R. Stinson, Virginia Department of Game and Inland Fisheries, Blacksburg

Pesticide Residues Measured in Fruits and Vegetables
J.B. Louis* and G. Post, Division of Science and Research, New Jersey Department of Environmental Protection, Trenton; M.G. Robson, Division of Rural Resources, New Jersey Department of Agriculture, Trenton; G.C. Mattern, Chao-Hong Liu, and J.D. Rosen, Department of Food Science, Rutgers University, New Brunswick, New Jersey

The Use of Membrane Vesicles as a Tool for Investigating Known and Potential Pesticides
M. Reuveni* and P.E. Dunn, Department of Entomology, Purdue University, West Lafayette, Indiana

Remediation of Herbicide Waste in Soil: Experiences with Landfarming and Biostimulation
A.S. Felsot* and E.K. Dzantor, Illinois Natural History Survey, Center for Economic Entomology, Champaign

Genetic Engineering of Plants: An Alternative to Synthetic Pesticides and a New Component of Integrated Pest Management
M.B. Sticklen*, Michigan State University, Plant Tissue Culture and Genetic Engineering Laboratory, East Lansing

Session K -- Pesticide Registration and Field Assessments

Moderator: Jean Gregory, Environmental Program Manager, Office of Environmental Research and Standards, Virginia Water Control Board, Richmond

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*Presenter

The Dissipation of Triclopyr in Lake Seminole, Georgia, Following an Aquatic Herbicide Application
P.L. Burch*, DowElanco, Raleigh, North Carolina; H.E. Westerdahl, Batelle Northwest, Richlands, Washington; K.B. Woodburn, DowElanco, Midland, Michigan; J.L. Troth, DowElanco, Indianapolis, Indiana

Dispersal and Degradation of Triclopyr Within a Boreal Forest Ecosystem Following an Aerial Application of GARLON 4* Herbicide
J.L. Troth*, DowElanco, Indianapolis, Indiana; D.D. Fontaine, DowElanco, Midland, Michigan; T.S. MacKay, DowElanco Canada, Inc., Etobicoke, Ontario; D.G. Thompson, Forest Pest Management Institute, Sault Ste. Marie, Ontario, Canada; G.R. Oliver, DowElanco, Indianapolis, Indiana

Quantitation of Nonpoint Source Pollution with Diazinon and Carbaryl
K.H. Deubert*, University of Massachusetts, Cranberry Experiment Station, East Wareham

Environmental Assessments of Agricultural Lands
A.J. Gordon* and K. Richardson, SCS Engineers, Reston, Virginia; B.F. Johnston, SCS Engineers, Phoenix, Arizona

Session L -- Pesticide Characteristics, Persistence, and Nontarget Effects

Moderator: Harry H. Gregori, Jr., Director, Office of Policy and Planning, Virginia Department of Waste Management, Richmond

Volatilization, Off-site Deposition, Dissipation, and Leaching of DCPA in the Field
L.J. Ross* and S. Nicosia, California Department of Food & Agriculture, Sacramento; M.M. McChesney, Department of Environmental Toxicology, University of California, Davis; K.L. Hefner, and D.A. Gonzalez, California Department of Food & Agriculture, Sacramento; J.N. Seiber, Department of Environmental Toxicology, University of California, Davis

The Influence of Climatic Variation on Pesticide Fate Predictions
B.R. Cuaresma Lobbe*, J.F. Dowd, and P.B. Bush, School of Forest Resources, University of Georgia, Athens

A Review of Methods for Assessing the Sensitivity of Aquifers to Pesticide Contamination
Jane G. Marshall*, U.S. EPA, Office of Groundwater Protection, Washington, D.C.

The Influence of Dormant Spray Oil on Diazinon Mass Deposition and Transfer to Nontarget Vegetation
B. Turner*, S. Powell, D. Gonzalez, C. Ando, and N. Miller, California Department of Food and Agriculture, Environmental Hazards Assessment Program, Sacramento

Session M -- Trends in Pesticide Use and Regulations

Moderator: Donald J. Lott, Regional Pesticide Expert, Toxics and Pesticides Branch, U.S. EPA Region III, Philadelphia

Cotton Pesticide Use and Pest Management
W.L. Ferguson*, Economic Research Service, Resources and Technology Division, Washington, D.C.

The Adoption and Implementation of Integrated Pest Management: Its Effects on the Level of Pesticide Use for California Pear Growers
A.M. Flynn Ridgley* and S.B. Brush, Applied Behavioral Sciences, University of California at Davis

*Presenter

The Use of Herbicides in the United States
L.P. Gianessi* and C.A. Puffer, Resources for the Future, Inc., Washington, D.C. **Trends in the Agricultural Use of Pesticides in New Jersey: 1978 Through 1988**
J.B. Louis*, Division of Science and Research, New Jersey Department of Environmental Protection, Trenton; M.G. Robson, Division of Rural Resources, New Jersey Department of Agriculture, Trenton; L.W. Meyer, Pesticide Control Program, New Jersey Department of Environmental Protection, Trenton

The Effect of Increased Pesticide Regulation on the Pest Control Industry in New Jersey
J.J. Pitonyak, Jr.*, L.W. Meyer, and R.C. Smith, Pesticide Control Program, New Jersey Department of Environmental Protection, West Trenton

Spatial Distribution Patterns and the Amount of Pesticides Used in U.S. Crop Production: Current Levels and Projections for 1995 and 2000
L.C. Thompson*, P.G. Lakshminarayan, J. Shogren, and S.R. Johnson, Department of Economics, Center for Agricultural and Rural Development, Iowa State University, Ames; J. Maetzold, USDA Soil Conservation Service, Washington, D.C.

Session N -- Model Testing and Validation

Moderator: Charles F. Finley, Jr., Executive Vice President, Virginia Forestry Association, Richmond

Using GLEAMS to Estimate Insecticide Movement from an Appalachian Mountain Pine Seed Orchard
L. Crawford*, J.F. Dowd, P.B. Bush, and Y. Berisford, University of Georgia, Athens; D.G. Neary, USDA Forest Service, University of Florida, Gainesville

Pesticide Transport Models: Comparison and Validation with Soil Column Leaching Experiments
T. Harter*, Department of Hydrology and Water Resources, University of Arizona, Tucson; and G. Teutsch, Institut für Wasserbau, University of Stuttgart, West Germany

Validity of Herbicide Prediction Models for Herbicide Movement in the Soil Vadose Zone
D. Penner, Department of Crop and Soil Sciences, Michigan State University, East Lansing; R.D. Shaffer*, USDA-Soil Conservation Service, East Lansing, Michigan

USDA Forest Service Aerial Spray Dispersion Models AGDISP and FSCBG I: Model Formulation
A.J. Bilanin and M.E. Teske*, Continuum Dynamics, Inc., Princeton, New Jersey; J.W. Barry, USDA Forest Service, Forest Pest Management, Davis, California; R.B. Ekblad, USDA Forest Service, Missoula Technology and Development Center, Missoula, Montana

USDA Forest Service Aerial Spray Dispersion Models AGDISP and FSCBG II: Model Validation
A.J. Bilanin and M.E. Teske*, Continuum Dynamics, Inc., Princeton, New Jersey; J.W. Barry, USDA Forest Service, Forest Pest Management, Davis, California; R.B. Ekblad, USDA Forest Service, Missoula Technology and Development Center, Missoula, Montana

Session O -- Nonagriculture Use and Local Management Planning

Moderator: Jay Roberts, Council on the Environment, Richmond

IPM Lawn Care in an Urban/Industrial Complex
P.E. Catron*, NaturaLawn, Inc., Damascus, Maryland

*Presenter

NATIONAL RESEARCH CONFERENCE, NOVEMBER 8-9, RICHMOND

Chlordane Residues in Soil Surrounding Houses in Louisiana
K.S. Delaplane*, Department of Entomology, University of Georgia, Cooperative Extension Service, Athens; J.P. La Fage (Deceased), Department of Entomology, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge

The Olmsted County Comprehensive Water Management Plan: A Strategic Planning Approach
G.C. Isberg*, Metropolitan Waste Control Commission, St. Paul, Minnesota

Comparison of IPM Programs of Three Commercial Landscape Maintenance Companies
E.P. Milhous*, White Oak Pest Management, Inc., Manassas, Virginia

Circle of Change
B.A. Mullarkey*, Wednesday Journal, Inc., Oak Park, Illinois

*Presenter

Presenters′ Abstracts

Session A -- Pesticides in Drinking Water Supplies

Moderator: John Johnson, Assistant Director of Public Affairs, Virginia Farm Bureau, Richmond

Herbicide Concentrations in Ohio's Drinking Water Supplies: A Quantitative Exposure Assessment
D.B. Baker*, Water Quality Laboratory, Heidelberg College, Tiffin, Ohio

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The Effects of Reporting Limits on Characterization of Presence of Pesticides and Nitrates in Groundwater
J. Briskin*, National Pesticide Survey, U.S. EPA, Washington, D.C.; D. Munch, U.S. EPA, Cincinnati, Ohio; R. Maxey, U.S. EPA, Bay Saint Louis, Mississippi

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Herbicides in Surface and Ground Water of Agricultural, Carbonate Valleys, Lancaster County, Pennsylvania
D.W. Hall* and P.L. Lietman, U.S. Geological Survey, Harrisburg, Pennsylvania

Herbicide Concentrations in Ohio's Drinking Water Supplies: A Quantitative Exposure Assessment

D.B. Baker[1]

To assess the human health risks posed by pesticides in Ohio's drinking water supplies, information is needed regarding both the concentrations and the toxicities of pesticides occurring in water supplies. The U.S. EPA has used available toxicity information to develop proposed maximum contaminant levels and health advisories for many of the most commonly used pesticides. These standards reflect concentrations which have either no or negligible adverse health effects for the public. Such standards are available for 92% by weight of the pesticides used in Ohio's agriculture. Two herbicides, atrazine and alachlor, make up 44% of the total tonnage of pesticides used in Ohio. The proposed standards for these compounds are 3 ppb and 2 ppb, respectively. Because they are relatively more toxic than currently used pesticides as a whole, they comprise about 77% of the "drinking water toxic load" of all pesticides used in the state.

Surface water provides the raw water supply for 55% of Ohio's 10.8 million residents. These surface supplies include Lake Erie, the Ohio River, rivers draining agricultural watersheds, pumped storage reservoirs, inland lakes, and on-stream reservoirs. About 1,200 public water supplies, serving 26.5% of Ohio's residents, utilize groundwater. An estimated 700,000 private wells serve the remaining 18.5% of the population. Using available monitoring data for atrazine and alachlor in all of the above sources, exposure assessments were developed for Ohio's entire population. For atrazine and alachlor, we estimate that 0.05% and 0.06% of the state's population are consuming water containing these compounds in excess of lifetime health advisory levels. These supplies are from private water supplies derived from shallow dug wells or from springs.

The statewide population-weighted-average concentrations for atrazine and alachlor are 0.29 and 0.095 ppb, respectively. The average concentrations of atrazine and alachlor in surface water supplies are 0.50 and 0.144 ppb, while the corresponding concentrations in groundwater are much lower, 0.036 and 0.035 ppb, respectively. The concentration estimates for groundwater are very likely overestimates because concentrations were less than detection limits for the vast majority of these supplies, and they were assigned concentrations equivalent to one half the detection limits.

The overall risk posed by these herbicides in drinking water appears to be very small. The observed alachlor concentrations should account for no more than one additional cancer in Ohio every 28 years. Atrazine apparently poses no risk to 99.95% of the population and only small risks to the remainder. Seasonal treatment to remove herbicides at a limited number of surface water supplies could greatly reduce current exposures, should such reductions be deemed appropriate. Any reductions in agricultural use of these compounds would be reflected immediately in reduced exposures because surface water supplies account for at least 15 times more exposure than groundwater supplies, and surface water concentrations largely reflect current year applications. Since other pesticides are used in either smaller quantities and/or are less toxic, the risks associated with their uses would be even lower than the small risks posed by alachlor and atrazine.

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Implementation of the National Survey of Pesticides in Drinking Water Wells

J.J. Boland[1]

The National Pesticide Survey (NPS) is a stratified random survey of both community water system (CWS) and rural domestic drinking water wells (DWS). The domestic well portion of the Survey is a three-stage design with stratification at the first two stages. The CWS component is a two-stage design with stratification at the first stage. The Survey goals are to 1. determine the frequency and concentration of pesticides in drinking water wells nationally and 2. examine relationships of pesticide contamination to patterns of pesticide use and groundwater vulnerability.

This presentation will focus on implementation issues which were critically important to the success of the Survey. The four areas that will be emphasized are Design, Chemical Methods, Health Advisories, and Communications.

The successful implementation of the Survey involved a multitude of federal, state, and local units of government, adherence to rigorous schedules and protocols, and complex logistics. These will be discussed in detail.

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The Effects of Reporting Limits on Characterization of the Presence of Pesticides and Nitrates in Groundwater

J. Briskin[1], D. Munch[2], and R. Maxey[3]

In conducting the National Survey of Pesticides and Nitrates in Drinking Water wells (National Pesticide Survey or NPS), EPA established reporting limits for each analyte: 126 pesticides and pesticide degradates plus nitrates. Reporting limits were chosen so that quantitative results were of known, acceptable precision. After initial analysis by gas chromatography (GC), positive samples were reanalyzed on a second gas chromatograph column. Samples which had positive results on both columns were examined by mass spectroscopy (MS) for positive identification of each analyte. For GC analyses, results were recorded as not detected, detected between one-half the method quantitation limit and the method quantitation limit, or as the quantitative concentration detected above the method quantitation limit. If different method quantitation limits (with different precision) had been selected, then the number of positive samples or positive samples with quantitative results might have been different. This difference could lead to important changes in the characterization of the extent of contamination of drinking water wells by pesticides and nitrates, with serious implications for state and federal policies for pesticides and nitrates in groundwater.

This paper examines the impact of selecting reporting limits on the depiction of the extent and severity of contamination of drinking water wells. A sensitivity analysis is performed to assess the impacts of alternative reporting limits on selected results from the NPS. Implications for careful interpretation and comparison of studies of pesticides and nitrates in water and suggestions for quality assurance guidelines for future studies are discussed.

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Results of the National Survey of Pesticides and Nitrates in Drinking Water Wells

J. Briskin[1] and J. Boland

The U.S. Environmental Protection Agency (EPA) conducted a national survey to learn about the prevalence of 126 pesticides and pesticide degradates plus nitrates in public and private drinking water wells. In addition to determining contamination rates for public and domestic water supply wells, the study was designed to investigate the relationship among contamination patterns, pesticide use, and groundwater vulnerability. The EPA will use the results of the survey to identify pesticides for possible future regulation in public drinking water supplies and to develop guidance information for state pesticide management plans which will be developed under the Agricultural Chemicals in Groundwater Strategy. After briefly describing the design and implementation of the survey, this paper will present the results of the survey and discuss implications of the results for future pesticide policies.

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Herbicides in Surface and Ground Water of Agricultural, Carbonate Valleys, Lancaster County, PA

D.W. Hall[1] and P.L. Lietman

Triazine herbicides and the herbicides alachlor and metolachlor have been found in surface and ground water supplies in agricultural areas of two separate watershed studies in Lancaster County, PA. Each of the watersheds is farmed intensively on the soils derived from carbonate rock, which comprise about 50% of the 148- and 188-square-mile drainage areas. These watersheds have been monitored by the U.S. Geological Survey since 1977 as part of the Chesapeake Bay and Rural Clean Water Programs. In both studies, monthly stream-water samples of base flow and samples of selected storm flows, representative of large multiuse basins and small intensively cropped (80 to 100% of total basin area) subbasins were analyzed for herbicides. In one study, water samples from domestic and monitoring wells also were analyzed periodically for herbicides.

Atrazine was the most widely used herbicide in the study areas and was the herbicide detected most frequently in water samples. Other herbicides that were often detected were simazine, cyanazine, alachlor, and metolachlor. Some herbicide concentrations were less than analytical detection limits at all sites, and the largest concentrations were found generally in the first surface or ground water samples collected after applications. In the large multiuse basins, the maximum atrazine concentration was 1.0 μg/L (micrograms per liter) in stream-base flow and 12 μg/L in stream storm flow. In the small intensively cropped subbasins, maximum concentrations were 3.9 μg/L in stream base flow and 210 μg/L in stream storm flow.

Atrazine was detected throughout the year in samples collected from about 40% of 28 domestic wells (100 to 200 feet deep) located in carbonate rock beneath agricultural areas, and the maximum concentration found was 3.0 μg/L. However, in 15 domestic wells located in noncarbonate rock or in carbonate rock beneath nonagricultural areas, atrazine was detected in only one well sample. The maximum atrazine concentration in water samples from two monitoring wells (75 to 125 feet deep) in carbonate rock beneath cropped land was 1.7 μg/L. Atrazine appeared in groundwater beneath this site within one day after the first recharge event following application to cropland, indicating rapid transport of atrazine from the land surface to the water table.

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Session B -- Policy and Decision-Making

Moderator: Jim Cox, Chief Engineer, Department of Conservation and Recreation, Division of Soil and Water Conservation, Richmond

Adoption of Alternative Management Systems to Improve Water Quality Under Uncertainty
P. Setia and D. Letson*, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Tipping the Scales: The Benefit Side of the Pesticide Risk-Benefit Balance
T. Shistar, National Coalition Against the Misuse of Pesticides, Lawrence, Kansas; S. Cooper*, National Coalition Against the Misuse of Pesticides, Washington, D.C.

A Decision-Making Framework for the Development of Agricultural Chemical Management Plans
E.P. Ditschman*, Institute of Water Research, Michigan State University, East Lansing; J.R. Black and J.P. Hoehn, Agricultural Economics, Michigan State University, East Lansing

Farmers' Reactions to Proposed Public Policies for Reducing the Risk of Water Contamination from Agricultural Pesticides
J.D. Esseks*, Center for Governmental Studies, Northern Illinois University, De Kalb;
D.R. Dyer, American Farmland Trust, Washington, D.C.; S.E Kraft, Department of Agribusiness Economics, Southern Illinois University, Carbondale

Setting a Place at the Table: Creating a Role for Agricultural Producers in Environmental Regulation
L. Elworth*, Pennsylvania Apple Marketing Program, Harrisburg, Pennsylvania

Adoption of Alternative Management Systems to Improve Water Quality Under Uncertainty

P. Setia and D. Letson[1]

Widespread concern about the deterioration of water quality from nonpoint sources has led to increased efforts to address this issue. Agriculture has been identified as a "primary" source of water pollution. Potential pollutants include sediment, pesticides, nutrients, and bacteria. Chemical residues from farm and forest lands can reach waterways through runoff and groundwater as soluble substances leaching through the soil. While existing types and levels of chemicals detected in the water samples may not have caused serious harm, the worry about long-term human health and environmental risks of higher concentrations is rapidly increasing. Public policies, in response to this concern, are designed to protect water quality but may have significant effects on agriculture. Any action that restricts chemical application or alters land-use methods will influence farm income and water quality. Since surface water systems and groundwater systems are linked, alternative management systems need to address water quality in both systems.

Although federal and state governments are concerned about controlling chemical residues entering the water sources, there is a need to examine the decision-making environment at the farm level. Implementing alternative management systems usually requires long-term investments. For environmental benefits to be realized in the long run, there must be sufficient incentives for farmers now. As a landowner's planning horizon increases, risk and uncertainty become increasingly important. Over time, it is difficult to predict farm income due to the variability in weather, crop yields, prices, and costs. When uncertainty about future benefits and costs is included in a plan, it reduces current income and increases current expenses, thereby making the investment decision less attractive. Hence, long-term planning is incomplete if it does not consider risk and uncertainty. Research indicates that uncertainty in farm income and farmer's attitudes toward risk may influence the adoption of alternative management systems. Hence, alternative management systems should be evaluated by incorporating uncertainty into the analysis.

We will use a simulation methodology (SECURE) to obtain the optimum combination of alternative management systems that maximizes net returns under uncertainty and accomplishes desired levels of reductions in soil loss and pesticide loadings to surface and ground water. The analysis is divided in two parts, namely i) technical and ii) policy-decision. The technical analysis draws upon data pertaining to site-specific physical and economic characteristics. Physical characteristics include soils, crop growth and yields, weather, technology, and pesticides (chemical properties, application rates, tillage practices, etc). The corresponding economic information consists of total operating costs and net returns. The technical analysis provides estimates of net returns, soil loss, variance-covariance of net returns and soil loss, chemical residue loadings to surface and ground water for each management system. This information is incorporated in a specially designed quadratic programming model to conduct policy-decision analysis. The programming model is capable of evaluating the impact of subsidies, taxes, land-use restrictions, ownership status, etc.

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Tipping the Scales: The Benefit Side of the Pesticide Risk-Benefit Balance

T. Shistar[2] and S. Cooper[1]

The study provides a critical analysis of the Environmental Protection Agency's pesticide benefits assessment process. The methodology currently in use at EPA was scrutinized, as well as Agency attitudes toward benefits assessment and the legislative history of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Three sample Agency benefits assessments were reviewed: the herbicide alachlor, the insecticide aldicarb, and the fungicide captan. Results suggest that the EPA has not adequately assessed available alternatives and has failed to include important factors in its benefits calculations, such as efficacy, secondary pest problems, development of pest resistance, and long-term impacts of cropping system changes. The historical survey of legislative history indicates that the "essentiality" clause should not prevent EPA from performing any aspect of a benefits assessment. A conceptual framework for benefits analysis is presented. Recommendations for administrative remedies involve: determination of a least toxic, best alternative for crop protection; consultation with experts in the field of alternative agriculture; performance of benefits assessment prior to registration; collection of additional data on efficacy, secondary pest infestations, and the development of resistance; and cluster analysis of pest control methods by crop/pest site. The authors suggest that EPA should become technology driving, and that future research is needed regarding relative fungal infestation rates of alternative and conventional growing systems and causal factors of detected differences.

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A Decision-Making Framework For The Development of Agricultural Chemical Management Plans

E.P. Ditschman[1], J.R. Black[2],
and J.P. Hoehn[3]

Due to the prevalent use of agricultural chemicals to enhance crop production and their potential for contaminating vulnerable aquifers, Michigan, along with other states, has come under Environmental Protection Agency (EPA) review for the development of agricultural chemicals in groundwater management plans (MPs). Recent surveys have indicated a wide variance in approaches to protecting groundwater from agricultural chemicals.

Four states—California, Wisconsin, Iowa, and Minnesota—have been selected as states with certain similar attributes to Michigan, yet each has different protection approaches at various stages of implementation. Each state program is the result of a unique set of circumstances. However, there has yet to be an extensive evaluation of the structure, conduct, and performance of programs designed to protect groundwater used for drinking water.

This research develops a decision-making framework for the development of MPs in Michigan with applications to other states. We used the Structure-Conduct-Performance framework (S-C-P), an applicable method for analyzing and comparing policy choices, to identify and evaluate the circumstances, interactions among policy community members, and decisions leading up to current structures and the conduct of affected entities. In particular, the relationships among the State Agriculture and Natural Resources Departments and the EPA are investigated along with a thorough evaluation of the impacts on the private sector, interest groups, and the end-user of agricultural chemical policy development. Appropriate models which satisfactorily evaluate the performance of these programs on groundwater quality and farmer safety are then identified.

The S-C-P is applied to each of the four states. The efficacy of each state's program is then scored in terms of costs including regulatory transactions costs in relation to groundwater damage costs. The cost effective components of each state are then input into an adaptive decision-making framework which enables state, local, and on-farm decision makers to choose better tools, techniques, and methods for the development of MPs designed specifically to meet state physical, socio-demographic, and economic circumstances.

The decision-making framework is then applied to the development of an agricultural chemical management plan for Michigan. The exercise included extensive interaction between the Michigan Departments of Agriculture and Natural Resources, Region V EPA, private interests, and Michigan State University. The resulting plan is evaluated and policy recommendations concerning the efficacy of the policy community are presented.

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Farmers' Reactions to Proposed Public Policies For Reducing The Risk of Water Contamination From Agricultural Pesticides

J.D. Esseks[1], D.R. Dyer[2], and S.E. Kraft[3]

This paper will report the findings of a telephone survey scheduled for June-July 1990 and planned to reach approximately 1,000 randomly selected farmers spread over 100 counties in 22 states. Representing the producers of six major agricultural commodities (corn, wheat, rice, cotton, peanuts, and dairy products), the interviewed farmers will be asked to respond to a number of policies that are either in the current draft of the 1990 Farm Bill (i.e., the draft as approved by the Senate Agriculture Committee) or that Conservation Coalition leaders will try to insert into the Bill during floor deliberations or at the conference committee stage. This survey is funded by the American Farmland Trust (AFT), a Washington-based nonprofit organization that focuses on conservation issues affecting agricultural land.

Most of the policy options to be presented to the surveyed farmers deal with ways to reduce the risk of water contamination from pesticides. These options include proposals for modifying the federal commodity programs to encourage crop rotations that should decrease the need for pesticides, requiring farmers in areas highly vulnerable to groundwater contamination to develop pesticide management plans that minimize the risk of contamination, mandating that all agricultural users of highly toxic pesticides (not just commercial applicators) keep usage records that would be accessible to public health authorities and also to agronomists concerned with developing practices for economizing on usage, and launching a governmental cost-sharing program that would provide multi-year grants to farmers who agree to apply practices that reduce the potential for water contamination.

The survey will also collect information about the structure of the farmer's operations and about his/her personal background. Such data will be used to determine whether attitudes toward the proposed policies differ significantly according to such variables. One or more attitude-predicting models will be tested.

By the time the conference is held, the 1990 Farm Bill should have been passed. For any of the policies covered in this survey that are included in the final Bill, we can report on likely reactions from the farming community and some of the determinants of those attitudes.

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Setting a Place at the Table: Creating a Role for Agricultural Producers in Environmental Regulation

L. Elworth[1]

The statutory regulation of pesticides has been a matter that primarily involved the registrant of a particular pesticide and the Environmental Protection Agency. However, the effects of regulatory actions on producers have been inadequately understood or represented. With the acceleration of the re-registration process as mandated under FIFRA 1988, the previously suspected but unspecified effects of regulation are beginning to reshape the methods available for agricultural production. This is being done in the absence of a comprehensive policy for how agriculture will or should look. Consequently, producers find that they must adapt to a situation to which policy makers have paid only minimal attention.

While producers are essentially a "third party" to the regulatory process, the involvement of such parties is firmly established. Indeed, much of the attention to pesticides is the result of aggressive and effective pressure from third parties in the environmental community. Agricultural producers have found themselves behind the curve in dealing with this process, despite the fact that recent issues have dealt severe blows to the marketability of products, such as apples.

In addition to the fact that producers do not have any legal standing in the actual registration process, there are a number of other reasons why the interests of producers have not been adequately represented. Political power has shifted with changes in demographics, thereby altering or diluting the power of traditional agricultural constituencies and agricultural committees in Congress. Regulatory oversight of agriculture has also shifted to agencies, such as EPA, which have relatively little understanding of agriculture and have responsibility for a myriad of other industries. For minor crop producers, the situation is exacerbated as they constitute a minority within a minority and have a relatively minor voice in the U.S. Department of Agriculture (USDA). Their situation is further complicated by lack of internal cohesion, lack of a coordinated public affairs agenda, shortage of resources and public affairs expertise, and inadequate coordination among the various minor crop groups.

The effects of last year's Alar controversy are only the most obvious results of this situation. The long-term effects are much more pervasive and continue to be evidenced in the progress of the regulatory process. For producers there are two possible options, neither of them mutually exclusive, for resolving the present problems. The short term option calls for individual groups to become more skillful in carrying their individual interests to the agencies and the Hill. For example, the dearth of information on how pesticides are used on a large number of crops provides an opportunity for specific producers to achieve a monopoly on the only credible and comprehensive information on their industries. In the long term, producers must begin to form and articulate a policy on regulation of agriculture that adequately considers the issues of alternative risk, resistance, the effects of production practices on overall risk reduction, incentives for adoption of innovative methods, and programs for making environmentally sound methods available to producers. Presently USDA and major producer organizations have failed to address these tasks in an appropriate or effective manner. However, in the absence of such an effort, the present regulatory scheme will continue to jeopardize the production and marketing of certain crops. It will also result in an agricultural production and marketing of certain crops. It will also result in an agricultural production system which is created by default rather than by design.

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Session C -- Pesticide Removal and Disposal

Moderator: S. Mason Carbaugh, Commissioner, Virginia Department of Agriculture and Consumer Services, Richmond

Removal of Pesticides from Contaminated Groundwater by Reverse Osmosis
A.M. Dietrich*, Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg; S.B. Chong, Los Angeles Water Authority, Azusa, California; M.A. Robinson, Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg; D.D. Ludwig, Engineering Fundamentals, Virginia Polytechnic Institute and State University, Blacksburg; J. Sherrard, Civil Engineering, Mississippi State University, Mississippi State

Studies on Demulsification and Sorption of Several Pesticides onto Lignocellulosic Substrates using Fluorometric and Gas Chromatographic Techniques
D.N. Judge* and D.E. Mullins, Department of Entomology, G.H. Hetzel, Department of Agricultural Engineering, and R.W. Young, Department of Biochemistry and Nutrition, Virginia Polytechnic Institute and State University, Blacksburg

Treatability of Pesticide Active Ingredients by Hydrolysis: Bench-Scale Treatability Study
D.A. Gardner*, Radian Corporation, Milwaukee, Wisconsin; E.A. Bicknell and J.R. Zimmerman, Radian Corporation, Herndon, Virginia

Treatability of Pesticide Active Ingredients by Membrane Filtration: Bench-Scale Treatability Study
G.L. Huibregste, Radian Corporation, Milwaukee, Wisconsin; E.A. Bicknell* and J.R. Zimmerman, Radian Corporation, Herndon, Virginia

Removal of Pesticides from Contaminated Ground Water by Reverse Osmosis

A.M. Dietrich[1], S.B. Chong,[2] M.A. Robinson[3],
D.D. Ludwig[4], and J.H. Sherrard[5]

Reverse osmosis is a powerful technique for removing soluble contaminants from water. This is a pressure driven separation process which utilizes a semipermeable membrane. Traditionally, reverse osmosis has been used to remove inorganic contaminants from water, such as the removal of salts in desalination. More recently, removal of dissolved organic contaminants in water has been investigated. This research investigated reverse osmosis for its ability to remove both inorganic ions and organic pesticides from contaminated groundwater in order to produce water suitable for drinking.

A 22 gal/minute reverse osmosis unit with a spiral wound polyamide membrane was evaluated. Specific pesticides investigated were 1,4-dichlorobenzene, atrazine, lindane, heptachlor, methoxychlor, pentachlorophenol, and 2,4,6-trichlorophenol. The groundwater contamination levels ranged from 10 μg/L to 500 μg/L. Pesticide concentrations were monitored at four locations in the reverse osmosis unit: 1) after the prefilter (designed to remove particulates that would clog the reverse osmosis membrane), 2) prior to the reverse osmosis membrane, 3) the concentrate or wastewater stream from the membrane, and 4) the permeate or purified water from the membrane.

The polyamide membrane effectively removed the pesticides from the groundwater; removal efficiencies were >98% for all seven pesticides tested. Final concentrations of the pesticides in the groundwater after reverse osmosis ranged from below detection to sub μg/L concentrations. Removal of the pesticides from the contaminated groundwater was shown to be the result of both reverse osmosis rejection and adsorption onto the polyamide membrane. Polyamide membranes are nonpolar membranes, and the results indicate that the more nonpolar pesticides (e.g., lindane) adsorbed more extensively to this membrane than the more polar pesticides (e.g., atrazine and pentachlorophenol).

The reverse osmosis unit tested was effective in producing potable water. With the exception of lindane, the permeate water from this reverse osmosis unit met the standards set by the Safe Drinking Water Act of 1974 and its 1986 Amendments.

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Studies on Demulsification and Sorption of Several Pesticides onto Lignocellulosic Substrates Using Fluorometric and Gas Chromatographic Techniques

D.N. Judge[1], D.E. Mullins,
G.H. Hetzel[2], and R.W. Young[3]

A pesticide waste disposal system using sorption/filtration and microbial degradation designed for pesticide applicators is being developed. The system employs lignocellulosic materials which remove pesticides from aqueous suspensions by sorption and filtration. The sorbed and filtered products are then placed in a bioreactor and provided with nutrients. The pesticide molecules are degraded by microbes in the bioreactor.

The sorption of 5,000 ppm chlorpyrifos (*Dursban*^{R} 4E; Dow) and diazinon (Diazinon 2E; Ciba-Geigy) was increased from approximately 40 percent to above 90 percent onto steam-exploded lignocellulosic wood products with the addition of $Ca(OH)_2$. However, studies concerned with optimizing demulsification and sorption of formulated pesticides proved to be time-consuming using conventional gas chromatographic techniques. In an attempt to expedite laboratory studies, the use of a fluorescent compound, 1,5-bis(5-phenyloxazolyl)benzene or POPOP as a pesticide model has been examined. Addition of POPOP to emulsifiable concentrates followed by dilution with water provided stable pesticide and POPOP emulsions which could be studied using fluorometry. The disappearance of POPOP fluorescence from a demulsified solution correlated closely with pesticide sorption. The developed fluorometric technique and gas chromatographic techniques were used to study and optimize the demulsification of several pesticide emulsifiable concentrate formulations and their subsequent sorption onto various lignocellulosic wood products and activated carbon. It appeared that there were different conditions needed for adequate demulsification of various pesticide emulsifiable concentrates. Also, lignocellulosic wood products appeared to be comparable to activated carbon in their sorptive qualities.

Major advantages of using a fluorometric technique developed here to evaluate demulsification/sorption processes is that it allows for 1) rapid evaluation of emulsion stability, 2) sensitive measurements in range of ng/L to mg/L, and 3) evaluation of demulsification of emulsions which may contain a variety of unknown compounds and surfactants.

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Treatability of Pesticide Active Ingredients by Hydrolysis: Bench-Scale Treatability Study

D.L. Gardner[1], E.A. Bicknell[2] and J. Zimmerman[2]

The objective of this laboratory study was to evaluate hydrolysis as a wastewater treatment technology in the pesticide industry. Radian conducted a series of bench-scale tests to determine the hyroloysis rates of selected pesticide active ingredients (PAI) in reagent grade water (i.e., not actual wastewater).

The tests were conducted at three different pHs (2, 7, and 12) and two different temperatures (20°C and 60°C). Thirty-eight PAIs separated into four test solutions were tested. The 38 PAIs were selected from a list of 272 PAIs supplied by EPA, with the selection criteria based on a variety of factors.

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Treatability of Pesticide Active Ingredients by Membrane Filtration: Bench-Scale Treatability Study

G.L. Huibregste[2], E.A. Bicknell[1], and J. Zimmerman[3]

The Industrial Technology Division, Office of Water Regulations and Standards, and the U.S. Environmental Protection Agency is conducting a major data collection effort for use in the development of effluent limitations, guidelines, and standards for the pesticide chemicals industry. The performance of various types of bench-scale and pilot-scale treatability studies is one part of this effort.

The objective of this study was to conduct a bench-scale program to evaluate membrane filtration as a method of pesticide removal. Seven different reverse osmosis (RO) membranes were tested on synthetic feed solutions containing 19 pesticide active ingredients (PAI). The RO membranes were manufactured from three different types of materials and were of various pore sizes. The PAIs were selected based upon several criteria which included chemical subgroup, priority ranking, analytical method, availability of other treatment data, and solubility in water.

The test results indicated that RO was an effective method of pesticide removal. The best results were obtained with the thin-film composite (TFC) membranes. Removals of 90 percent or greater were obtained throughout the test, with the majority of PAIs being rejected at 99 percent or greater. The cellulose acetate (CA) membranes initially achieved removals which were in most cases similar to the TFC membranes. However, for five of the PAIs, the rejection declined significantly between the beginning and the end of the six hour run. The third type of membrane, which was made from aramid, achieved removals similar to the CA, but the removal did not change during the run.

For ten of the PAIs, the rejection was a function of the membrane pore size. With a few exceptions, those PAIs which had a lower percent removal with the larger pore membranes had molecular weights in the 200-240 range.

For eight of the PAIs, over 80 percent of the raw material initially added was no longer present in the feed solution at the end of the run. The PAI material which was unaccounted for was believed to have been adsorbed to the RO membrane. Overall, the amount of PAI adsorbed was slightly higher for the cellulose acetate membranes.

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Session D -- Testing and Monitoring

Moderator: Edward E. LeFebvre, Director, Bureau of Chemistry, Division of Consolidated Laboratory Services, Virginia Department of General Services, Richmond

Synthetic Resins as Monitoring Tools
T. Shearer* and J.W. Bishop, Department of Biology, University of Richmond, Richmond, Virginia

Evaluation of the Role of Diazinon in the Toxicity of a Municipal Wastewater Treatment Plant Effluent
J.A. Botts* and L. Fillmore, Engineering-Science, Inc., Fairfax, Virginia; E. Durhan, U.S. EPA, Environmental Research Laboratory, Duluth, Minnesota; T. Pereira, Public Works Commission, Fayetteville, North Carolina; D.F. Bishop, U.S. EPA, Risk Reduction Research Laboratory, Cincinnati, Ohio

Comparative Toxicokinetics of Carbaryl Using a Sensitive HPLC Method
M. Ehrich*, J. Wilcke, L. Correll, J. Strait, G. Thornwall, and W. McCain, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Polytechnic Institute and State University, Blacksburg

Quantification of Chlorinated Hydrocarbon Pesticides in Biological Specimens: Plasma, Fat, and Stool
J.J. Saady* and A. Poklis, Department of Pathology, Medical College of Virginia, Virginia Commonwealth University, Richmond

Synthetic Resins As Monitoring Tools

T.L. Shearer[1] and J.W. Bishop

Amberlite XAD-2 resin was examined as a possible tool for the quantitative monitoring of pesticides in water. The objective was to compare the efficiencies with which the pesticide, Lindane , was adsorbed to and desorbed from the columns of resin. Laboratory methods for measuring pesticides were developed using Lindane in distilled water using different solvents, solvent volumes, and desorption times. The methods then were applied to samples of Lindane in water containing suspended matter.

Distilled water containing Lindane was passed through a column of resin. Lindane was rinsed from the column using diethyl ether, methylene chloride or methanol. Volumes of solvent used to desorb the Lindane were 10-30 ml and the desorption times ranged from 0-60 minutes. The concentrations of Lindane were measured by gas chromatography and compared. The desorption efficiencies were taken as the quotients of the amount of Lindane in the solvent rinse divided by the amount of Lindane originally passed through the column.

Thirty ml of diethyl ether and fifteen minutes for desorption were determined to be adequate for the study.

In order to simulate field conditions, combinations of different amounts of suspended matter and different organic concentrations were added to the solutions of Lindane. The efficiencies of the different combinations were described.

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[1] **Presenter**

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Evaluation of the Role of Diazinon in the Toxicity of a Municipal Wastewater Treatment Plant Effluent

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T. Pereira[3], and D.F. Bishop[4]

Many municipalities are being required to monitor the effluents of their wastewater treatment plants for aquatic toxicity under the National Pollutant Discharge Elimination System (NPDES). If an effluent is found to have unacceptable levels of acute and/or chronic toxicity, the NPDES regulatory agency may require the municipality to initiate a Toxicity Reduction Evaluation (TRE). The purposes of a TRE is to determine the nature and source(s) of the effluent toxicity and implement a strategy for controlling the toxicity.

EPA has developed procedures for identifying the compound(s) causing effluent toxicity. These procedures, referred to as Toxicity Identification Evaluation (TIE) tests, were applied to the effluent of the Cross Creek Wastewater Treatment Plant in Fayetteville, North Carolina. The results of initial TIE tests using a C_{18} solid phase extraction column indicated an association of effluent toxicity with nonpolar organic compounds. The acute toxicity of the effluent (average *Ceriodaphnia* 48-hr $LC_{50} = 35\%$) was completely eliminated by passing the effluent through the C_{18} column (*Ceriodaphnia* 48-hr $LC_{50} = 100\%$). The nonpolar organic toxicity was quantitatively recovered by eluting the C_{18} column with methanol. In subsequent TIE tests (Phase II) a HPLC column was used to concentrate and isolate the nonpolar toxicant(s) into a series of methanol eluates. GC/MS analysis of the toxic eluates found diazinon, an organophosphate pesticide, at concentrations high enough to cause the majority of the effluent toxicity (0.6 μg/L). Other evidence that diazinon is an effluent toxicant included a reduction of toxicity following pH 3 adjustment and the higher sensitivity of *Ceriodaphnia* to the effluent compared to *Pimephales promelas*.

A survey is being conducted to locate the sources of diazinon in the sewer collection system. Approximately eleven sampling points have been assigned so that diazinon can be systematically tracked through the collection system. The survey will involve an evaluation of the contribution of diazinon by suspected sources including commercial pesticide applicators, waste haulers, and households. A description of the modified GC/MS analytical method will be presented along with a discussion of the problems encountered in diazinon analysis of raw sewage. In addition, this paper will discuss the implications of controlling effluent toxicity that is caused by a widely used pesticide.

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Comparative Toxicokinetics of Carbaryl Using a Sensitive HPLC Method

M. Ehrich[1], J. Wilcke, L. Correll, J. Strait, G. Thornwall, and W. McCain

Carbaryl and metabolites were detectable in low concentrations in serum of rats and chickens after intravenous and oral administration using HPLC analysis. Sensitivity of the HPLC method allowed for detection of 1 ng of carbaryl applied to a 4 cm, 3 micron, C_{18} reverse phase column, with carbaryl and 9 metabolites eluting from the column in less than 10 minutes. One-step sample preparation of filtered serum was done by extraction with methanol on a 1.0 ml solid phase extraction column (C_{18} bonded silica gel).

Sensitivity to carbaryl varies among species, with the rat being relatively sensitive and the chicken being relatively resistant. For example, equivalent inhibition of the target enzyme acetylcholinesterase was seen after administration of 70 mg/kg and 900 mg/kg to the rat and chicken, respectively. When 100 mg/kg carbaryl was administered by the oral route, plasma levels were significantly higher in rats than in chickens one hour later ($1{,}283 \pm 253$ and 271 ± 32 ng/ml, respectively, mean ± standard error, $n=5$ and 6). Clearance after intravenous administration of 5 mg/kg carbaryl was rapid in the chicken. The clearance curve was pharmacokinetically described as a 2-compartment open model, with the constant for elimination from the central compartment calculated to be 0.11^{-1}. Pharmacokinetic studies also indicated that the volume of distribution when carbaryl was at steady state was relatively large in the chicken (8.47 ± 1.98 L/kg, mean ± standard error, $n=6$). Total clearance was 0.26 ± 0.02 L/kg/min, which is high enough to contribute significantly to the relative insensitivity of chickens to carbaryl. These toxicokinetic differences contribute to species differences in insecticide toxicities, which are an important consideration in risk assessment.

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Quantification of Chlorinated Hydrocarbon Pesticides in Biological Specimens: Plasma, Fat, and Stool

J.J. Saady[1] and A. Poklis

Pesticides and their metabolites are extracted and concentrated from plasma using C_{18} solid phase extraction cartridges. Four ml of serum or plasma, to which an aldrin internal standard is added, are treated with 2 ml of methanol and the resultant supernatant applied to the C_{18} cartridge. After several washes, pesticides are eluted from the column with iso-octane and the eluate quantified with capillary gas chromatography using electron capture detection (GC-ECD). Fat samples are processed similarly but first extracted with hot petroleum ether, using the method of Mills, Onley, and Gaither. Extraction efficiency is from 70 percent to 75 percent and the detection limit for the ranges from 0.1-0.7 ng/ml depending on the analyte. Precision studies demonstrate that Coefficients of Variation range from 3.5 to 25.2 percent. Standard curves are linear to at least 7 ng/ml for lindane and chlordane isomers, heptachlor, heptachlor epoxide, oxychlordane, trans-nonachlor, dieldrin, dichlorodiphenyldichloroethylene (p,p′-DDE), dichlorodiphenyldichloroethane (p,p′-DDD), and dichlorodiphenyltrichloroethylene (p,p′-DDT). For stool samples, p,p′-DDE and p,p′-DDT are extracted from 4 g of stool using 7 ml hexane (x3), followed by sulfuric acid washes (x3). The hexane extract is evaporated and quantified by GC-ECD. The quantitative range is from 20-2,000 ppb for p,p′-DDE and 20-400 ppb for p,p′-DDT. Extraction efficiency is 86-98 percent. These methods circumvent the long and tedious sample preparation method of fluorisil column cleanup.

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Session E -- Pesticide Degradation in Soils

Moderator: Joel Artman, Chief, Pest Management, Virginia Department of Forestry, Charlottesville

Pesticide Leaching and Persistence in a Coastal Plain Soil in Virginia

C.D. Heatwole*, S. Mostaghimi, T.A. Dillaha, Department of Agricultural Engineering, and R.W. Young, Department of Biochemistry and Nutrition, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Herbicide Sorption and Mobility in Delaware Soils

R.M Johnson* and J.T. Sims, Department of Plant and Soil Science, University of Delaware, Newark

Effects of Mineral and Soil Surfaces on the Chemical Degradation of Atrazine: A Critical Review

J. Schmidt*, Analytical Bio-Chemistry Laboratories, Inc., Columbia, Missouri

Pesticide Leaching and Persistence in a Coastal Plain Soil in Virginia

C.D. Heatwole[1], S. Mostaghimi[2], T.A. Dillaha[3], and R.W. Young[4]

Intensive sampling and field monitoring is being used to characterize the fate and transport of three pesticides (atrazine, metolachlor, carbofuran) in the soil profile under no-till and conventional-till corn in the Coastal Plain of Virginia. The project incorporates (a) data collection to assess the threat of pesticide movement to groundwater in the high-risk coastal plain region, (b) data collection to support evaluation and validation of groundwater management models, and (c) an analysis of the potential that current agricultural practices have for contaminating groundwater with pesticides, focusing on the impact of conservation tillage practices which are being supported by the state cost-share program.

Two plots of 18 X 27 meters are located side-by-side with a 6-m buffer between them. The study site is in a field that is in the second year of a no-till (wheat-beans-corn) rotation. One plot was plowed and disked before corn was planted. Typical management and tillage practices are being used on the plots during the study so that the site is representative of actual agricultural practices. Replicate (n = 20) soil core samples are collected from each plot at one day and 1, 2, 4, 7, 12, and 20 weeks following pesticide application. Soil samples are collected to 1.2 m and separated into seven depth increments for analysis. Basic surface hydrology and runoff water quality are also measured. Preliminary results show the potential for rapid movement of solutes through the root zone. Losses of pesticides in surface runoff and leaching and persistence of the three pesticides in the soil for the two tillage treatments will be compared.

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Herbicide Sorption and Mobility in Delaware Soils

R.M. Johnson[1] and J.T. Sims

The sorption and mobility of atrazine and metolachlor was studied on five Delaware Coastal Plain soils. The soils were collected from a single watershed and include one well- drained, three moderately well-drained, and one poorly drained soil. All soils were sampled by horizon to the water table. Two techniques were utilized to obtain sorption and mobility data. Sorption isotherms were constructed by a modified batch procedure. The principal modification was a pre-equilibration procedure, in which the herbicide was equilibrated for 24 hours prior to addition of soil. The procedure was used to account for herbicide sorption to centrifuge tubes. The second procedure utilized was soil thin layer chromatography (TLC). In this procedure, a soil slurry was spread on a glass plate to a thickness of 1000 μm and allowed to dry. ^{14}C-labeled herbicides were then spotted 2 cm from the base and the plate was developed by ascending chromatography with deionized water as the solvent. After development, the plates were allowed to dry and then analyzed first by autoradiography and then by zonal extraction and scintillation counting. Distribution coefficients (Kd) were calculated from both procedures. In the soil TLC procedure this was accomplished by determining the point of maximum concentration on the plate (Rm) and then applying chromatography theory, where $Kd = As/Am(1/Rm-1)$ and the ratio As/Am is the ratio of the areas of the liquid and mobile phases. After preliminary analysis of the data, we observed a disparity in the Kd values as calculated from each procedure. The Kd values for atrazine were generally greater in the soil TLC procedure. To investigate this effect further, correlation analysis was performed between Kd values from each procedure and selected soil properties. In general, those properties closely associated with water flow and structure, such as clay and sesquioxide content were more highly correlated with the TLC estimate and those properties related to acidity and organic matter were more highly correlated to the batch estimate. The importance of soil organic matter was also decreased or eliminated when surface soils were excluded from the analysis. It is suggested that the soil TLC procedure, because it is a dynamic technique involving transport, may be yielding non-equilibrium results that may be more applicable to the field environment.

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Effects of Mineral and Soil Surfaces on the Chemical Degradation of Atrazine: A Critical Review

J. Schmidt[1]

Atrazine is a widely used selective herbicide for the control of broadleaf and grassy weeds in a variety of crop types. It has been detected in groundwater across the United States at a greater frequency than other currently used pesticides. Its prevalence is a function of its persistence, moderate mobility, and, perhaps most significantly, its widespread use. The chemical hydrolysis of atrazine has been found to be a primary pathway for its degradation. The purpose of this paper is to provide a current review of the literature pertaining to the hydrolysis of atrazine in the mineral/soil environment. It serves as a foundation for a more extensive review of the chemical degradation of atrazine, with attention given to the various primary and secondary factors that affect the hydrolysis of organic chemicals.

Mineral surface area in contact with groundwater is immense, thus it is important to determine whether mineral surfaces can enhance the hydrolytic degradation of otherwise refractory compounds, such as atrazine. Mineral surfaces can influence the transformation of organic compounds in several ways, including the promotion of oxidation-reduction reactions, specific adsorption or co-adsorption with subsequent alteration of reaction rates, and through the unique chemical microenvironments at the mineral/water interface.

Atrazine has been observed to degrade much faster when exposed to mineral or soil surfaces than predicted from results of experiments in aqueous solution, and most of the factors described earlier may be important. In a broader sense, this review demonstrates the complexity of investigating the environmental fate of any important pesticide. Simple experiments where the degradation of a chemical is followed in aqueous solutions of differing pH can give a relative sense of the importance of hydrolysis for those compounds that are prevalent in our soils and groundwater, but it explains little. The review indicates the importance of investigating secondary parameters when predicting the environmental fate of a chemical in the field.

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Session F – Analytical Procedures and Assays

Moderator: David D. Effert, Technical Services Chief, Division of Sanitarian Services, Virginia Department of Health, Richmond

Quantitative Enzyme Immunoassays of Pesticides in Water, Soil, and Foods at Part Per Billion Levels
R.O. Harrison* and B.S. Ferguson, ImmunoSystems, Inc., Scarborough, Maine

A New Method for Detecting Genotoxic Chemicals in Water or in Environmental Samples
K. Schurr* and H. Xu, Department of Biological Sciences, Bowling Green State University, Bowling Green, Ohio

New, Rapid Gas Chromatographic/Mass Spectrometric Analytical Procedure for Insect Growth Regulator Diflubenzuron
M.J. Wimmer*, Department of Biochemistry, West Virginia University Health Sciences Center, Morgantown; R.R. Smith, Department of Biochemistry, Mass Spectrometry Center, West Virginia University, Morgantown; J.J. Jones, Department of Pharmacology, University of Rochester Medical Center, Rochester, New York

Quantitative Enzyme Immunoassays of Pesticides in Water, Soil, and Foods at Part Per Billion Levels

R.O. Harrison[1] and B.S. Ferguson

Over the past 15 years, immunoassays—particularly enzyme immunoassays (EIAs)—have become very popular in human and veterinary diagnostics. Applications in these markets include drug-of-abuse testing, therapeutic drug monitoring, endocrine and vitamin tests, and a whole range of protein, viral, and bacterial assays. The widespread popularity of EIAs has spread and will continue to spread out into environmental applications.

EIAs are an antibody-based technique combining the analyte-binding properties of the antibody with the signal amplification advantages of an enzyme. Although many varieties of EIAs (or ELISA for Enzyme Linked ImmunoSorbent Assays) exist, the format described herein utilizes antibody-coated plastic tubes or microwells. The antibodies to various pesticides were raised in rabbits and immobilized onto the solid phases by a proprietary process that provides long-term stability and reactivity. The sample analyte (pesticide) plus peroxidase "tagged" pesticide reagent are simultaneously added to the tube or well and "compete" for the antibody. Following a wash step and substrate addition, color is generated and the results are interpreted: the lower the color, the greater the pesticide concentration. The concentration of analyte in the sample can be determined by comparison of the sample color to a standard curve prepared in parallel.

Already, several pesticide enzyme immunnoassays have been produced at the research level. A number of assays have proven themselves appropriate for environmental analysis, including EIAs for chlorsulfuron, atrazine, heptachlor, aldicarb, carbofuran, metalaxyl, benomyl, diclofop, and 2,4-D. ImmunoSystems, however, was the first to successfully commercialize immunoassay kits for pesticide detection. Accuracy, precision, and sensitivity (with little or no sample preparation) of these methods are competitive with chromatographic methods. At the same time, the cost per sample is often five- to ten-fold lower and turnaround time is dramatically reduced . The data presented will illustrate the use of these rapid, simple, sensitive, and inexpensive tests for the on-site (field) or laboratory investigation of common water, soil, and food contamination problems.

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A New Method for Detecting Genotoxic Chemicals in Water or in Environmental Samples

K. Schurr[1] and H. Xu

The genetically modified starting of *Escherichia coli*, K-12 PQ37 reacts to the injury of DNA by exhibiting the SOS response. The dosage dependent production of beta-galactosidase after exposure to a genotoxic chemical and the photometric assay of this enzyme provide the basis for the highly respected SOS Chromotest. However, we found that genotoxic chemicals also affected the normal growth and structure of this strain of *E. coli*. Electron photomicrographs of the bacterial cells revealed filamentous growth and failure of the development of normal crosswalls. Dosages of 0.125 mg/L of Captafol, for example, produced obvious cytological changes. We propose a numerical analysis for documenting genotoxic pollutants with electron photomicrographs of the altered cells as evidence. This is a rapid, uncomplicated assay with the photomicrographs serving as permanent documentation of the results.

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New, Rapid Gas Chromatographic/Mass Spectrometric Analytical Procedure for Insect Growth Regulator Diflubenzuron

M.J. Wimmer[1], R.R. Smith[2], and J.J. Jones[3]

A new and rapid gas chromatographic/mass spectrometric analytical procedure for insect growth regulator diflubenzuron (trade name Dimilin) has been developed. The method overcomes the main problem with chromatographic techniques which use ultraviolet absorption detection, that is, interference from co-extracted compounds when dealing with complex environmental samples such as leaves, leaf litter, bark, and biological tissues. Similar to other phenylurea-based pesticides, diflubenzuron is decomposed by the heat of a gas chromatograph. These breakdown products have been identified as three reproducible fragments which elute separately from the GC column: 4-chlorophenylisocyanate, 4-chloroaniline, and 2,6-difluorobenzamide. Purified 4-chlorophenylisocyanate partially decomposes to 4-chloroaniline during gas chromatography and is thus the likely source of the 4-chloroaniline above. Therefore, one heat-labile bond appears to exist within the urea moiety of diflubenzuron, and that bond is different from the bond cleaved during based-catalyzed hydrolysis or microbial degradation in the environment. Advantage is taken of this, and the use of mass spectrometry along with an internal standard of diflubenzuron which has been deuterated in the 2 and 6 positions of the chlorophenyl ring, to quantify diflubenzuron in simple or complex samples. The two heat-generated chlorophenyl fragments each contain the deuterium label isotopically diluted by any protio-diflubenzuron in the original sample. No isotope effect is expected in the fragmentation reaction as the deuterium atoms are several bonds distant from the heat-induced cleavage point. A straightforward calculation from the H/D ratio within each fragment peak, correcting for chlorine-37 natural abundance from the protio species, results in the μg of diflubenzuron. An internal check is provided because in the absence of any chloroaniline or chlorophenylisocyanate in the original sample, the two fragments should show identical H/D ratios, and this is observed. No sample derivatization is required. By doing selected ion monitoring for only those specific major ions of interest from the diflubenzuron fragments, interference from co-extracted compounds is removed making sample purification steps unnecessary. Detectability levels are similar to or better than currently-used methods. Extraction of diflubenzuron from dosed fresh or dried leaves demonstrates the selectivity and utility of the technique.

This research was supported in part by a grant to MJW from the U.S. Department of Interior as authorized under the Water Research and Development Act of 1978.

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Session G -- Economic and Environmental Tradeoffs

Moderator: George Gilliam, Chairman, Department of Agriculture and Consumer Services, Pesticide Control Board, Richmond

An Integrated Model of Agricultural Production and Water Quality: Application to Pesticides, Surface Water, and Ground Water
S.R. Crutchfield* and R.J. Brazee, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Economic and Environmental Implications of Planting Herbicide Resistant Corn in Iowa
S.K. Kaaria*, L.C. Thompson, and M.L. Hayenga Department of Economics, Iowa State University, Ames

Examining the Trade-off Due to Policies Regulating Agrichemical Use: An Application to U.S. Agriculture
P.G. Lakshminarayan*, J.D. Atwood, L.C. Thompson, J. Shogren, and S.R. Johnson, Department of Economics, Center for Agricultural and Rural Development, Iowa State University, Ames; J.A. Maetzold, USDA, Soil Conservation Service, Washington, D.C.

Environmental and Productivity Impacts of Pesticide Practices: EPIC-PST Simulation
G.J. Sabbagh, Department of Agricultural Engineering, P.E. Norris*, Department of Agricultural Economics, S. Geleta, Department of Agronomy, D.J. Bernardo, Department of Agricultural Economics, R.L. Elliott, Department of Agricultural Engineering, H.P. Mapp, Department of Agricultural Economics, and J.F. Stone, Department of Agronomy, Oklahoma State University, Stillwater

Effects of Agricultural Pesticides' Use Restrictions in the United States
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An Integrated Model of Agricultural Production and Water Quality: Application to Pesticides, Surface Water, and Ground Water

S.R. Crutchfield[1] and R.J. Brazee

The impact of agricultural production on water quality has figured prominently in the agro-environmental policy debate in recent years. The recent policy emphasis on controlling these externalities has been fueled by increasing concern about the presence of pesticides in groundwater and the increasing emphasis on reducing agricultural nonpoint source pollution of surface water. Renewed attention has been placed on the relationships between decisions made by farmers regarding pesticides and the on- and off-farm degradation of water quality from pesticides.

Economists have long recognized a fundamental externality: agricultural inputs that cause off-farm environmental degradation (particularly chemicals and eroded soils) are not fully priced in the market to reflect the economic costs of their use. Pesticides and sediment flow via soil erosion to surface waters. These residuals and sediment degrade the quality of the receiving water. The economic costs of impaired water quality to users of lakes, streams, and reservoirs are not fully reflected in the producers' costs of the agricultural inputs. Pesticides may also leach through the soil profile into groundwater, causing at least the potential for a variety of adverse effects on the health of humans and livestock who use contaminated groundwater.

This paper presents a simplified model of the relationship between agricultural production and the resulting impacts on water quality. We developed a model to explain the linkages between crop production, pesticide use, soil loss, surface water quality, and groundwater quality. The offsite impacts of pesticides and soil erosion on surface and ground waters are incorporated in an integrated model of agricultural production. The interdependencies of ground and surface water quality are highlighted. The economic and environmental implications of soil conservation and pesticide regulation programs are evaluated. The effectiveness of chemical use and soil erosion restrictions in protecting water quality are compared and contrasted.

For the most part previous economic analyses of soil erosion, agricultural externalities, and water quality have examined one resource issue: surface water, groundwater, or the on-farm productivity effects of eroding soils. To date, few studies have considered the dual objectives of protecting both surface and ground water from agricultural externalities.

A key feature of the model developed here is that it explicitly considers the trade-off between protecting surface water from eroding soils and farm chemicals in runoff and protecting groundwater from leaching chemicals applied to cropland. Surface water and groundwater quality are not really separable issues: efforts to restrict transport of pesticide residuals in one medium (soil, groundwater, surface water, or air) may increase residual flows in other media.

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Economic and Environmental Implications of Planting Herbicide Resistant Corn in Iowa

S.K. Kaaria[1], L.C. Thompson, and M.L. Hayenga

What implications will the introduction of herbicide resistant corn have for Iowa corn producers? Adoption of this new technology will depend on the economic and environmental tradeoffs currently being debated. This study was conducted to estimate changes in cost of production of corn associated with using herbicide resistant varieties and to assess potential environmental benefits from the shift in pesticide management. Partial budgeting procedures were used to compare costs of production of corn enterprises in Iowa, given, the new technology would allow farmers to use broad spectrum herbicides for the management of weed pests and a different sequence of preharvest field operations compared to traditional practices. Potential environmental impacts were assessed for each production technology by computing soil-pesticide interaction ratings which are indicative of a pesticide chemical's potential to become a nonpoint source pollutant. Results indicate that the use of herbicide resistant corn varieties would result in less total and fewer types of herbicide compounds being used on planted acres of corn through the elimination of pre-plant and pre-emergence herbicide applications. Preharvest machinery and labor costs were estimated at 21 percent lower for acres planted with herbicide resistant corn. Although the per acre cost for seed and chemical inputs was estimated to increase by 3 percent, yields were assumed higher by 3 percent resulting in an estimated 5 percent lower cost of production per bushel of corn produced. For an Iowa farm planting 500 acres of herbicide resistant corn and assuming an average yield of 118 bushels per acre, the total cost savings amounts to over $8,000. In terms of environmental impacts, however, clear tradeoffs exist stemming from differences in the herbicide compounds tendency to move in the environment through leaching or surface runoff.

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Examining the Trade-off Due to Policies Regulating Agrichemical Use: An Application to U.S. Agriculture

P.G. Lakshminarayan[1], J.D. Atwood, L.C. Thompson
J. Shogren, S.R. Johnson and J.A. Maetzold[2]

Nonpoint source pollution of water resources by agrichemicals has evoked great concern, particularly nitrate pollution. One proposed solution to nitrate pollution is to consider an ad hoc regulatory policy such as a use tax on commercial nitrogen (N) fertilizer. Producers use an optimum combination of N and pesticides. Any policy regulating the use of N, and hence increasing the risk from production uncertainty, will be offset by alternate cropping and management practices and factor substitution that affects the level of pesticide application. However, the net impact of these potential responses to a N tax on pesticide use is unknown. Thus, such regulatory policies targeted at a single pollutant are likely to induce a major trade-off between N and pesticide use, which may complement broader environmental objectives or conflict with them. A regulatory policy that is optimal from the perspective of reducing nitrate pollution may be sub-optimal with respect to other environmental pollutants. This study examines the agrichemical use trade-offs resulting from a policy prescribing a five-cent tax per lb of N fertilizer. We examine the consequences of this policy on pesticide use patterns and quantities, regional shifts in cropping patterns, and shifts in regional chemical use.

The Agricultural Resources Interregional Modeling System (ARIMS), which is a national-level resource use model developed for the second Resource Conservation Act appraisal, is used. The model has 105 crop production regions and 31 market/livestock production regions. Production technology and environmental impact information in ARIMS is derived from the Erosion-Productivity Impact Calculator. Crop production possibilities, including rainfed and irrigated production, major soil conservation tillage practices, crop rotations, and alternative levels of conservation treatment, are specified in the model. The input use coefficients are adjusted to reflect the relative price changes in N associated with the tax. Given predetermined yields, the model estimates N requirements using a simple yield response function. The model is linked to a pesticide data base that describes the sets of chemicals, the percentage share of each chemical, and the recommended application rates for each crop/tillage combination.

Cropping pattern, yield, nitrogen, and pesticide levels and mixes are estimated for the 1990 baseline. The pre- and post-tax solutions are used to estimate regional pesticide use patterns and levels in terms of pounds of active ingredient (ai) of each chemical. The five-cent N tax led to a 10 percent decline in national N fertilizer use but was accompanied by a 2 percent (6 million lbs of ai) increase in pesticide use. The use of atrazine increased by nearly 4 percent. The shifts in chemical use patterns show a potential to increase rather than decrease the threat to surface and ground water. The results support the need for a comprehensive agrichemical policy rather than the superficial policy of a user tax on N fertilizer.

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Environmental and Productivity Impacts of Pesticide Practices: EPIC-PST Simulation

G.J. Sabbagh[2], P.E. Norris[1], S. Geleta[3],
D.J. Bernardo[4], R.L. Elliott[2], H.P. Mapp[4],
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There is growing concern over potential contamination of groundwater by agricultural chemicals. The likelihood of contamination differs widely across the United States as critical physical factors such as soil type and depth to groundwater vary. As changes in pesticide use restrictions and water quality policies are deliberated, agricultural producers in some areas fear overly restrictive policies which may needlessly jeopardize financial returns. This paper will report results from a part of a larger interdisciplinary research project funded by the U.S. Geological Survey. It will present an evaluation on the environmental and economic impacts of alternative chemical pest control methods practiced by producers in the high plains region of Oklahoma. To simulate the processes needed in the project, the EPIC-PST computer model was developed by incorporating the chemical-related subroutines from the GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) model into the Erosion Productivity Impact Calculator (EPIC). This incorporation was accomplished by unifying the format of parameters common to both models and eliminating from the pesticide section the processes available in EPIC. EPIC-PST is capable of simulating simultaneously the effect of different agricultural management practices on crop yield and the pesticide losses by surface runoff, sediment movement, and leaching below the root zone. For the study, typical and alternative crop management practices were identified and the EPIC-PST model, using twenty years of weather records from Goodwell, Oklahoma, was used to simulate resulting yields and pesticide losses. The simulation was conducted for irrigated corn and grain sorghum, where chemical use is intensive. The soils identified for this study are Richfield Clay Loam, Richfield Fine Sandy Loam, and Dalhart Loamy Fine Sand. Results of the simulation, combined with economic analysis, were used to illustrate potential trade-offs between environmental and economic production costs and returns resulting from changes in chemical management practices. The outcome of this study provides information on the relative risk of pesticide leaching in the high plains of Oklahoma and also presents an understanding of the potential economic impact of required changes in production practices.

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Effects of Agricultural Pesticides' Use Restrictions in the United States

P. Setia[1] and K.A. Algozin

The effectiveness of modern agricultural chemicals in maintaining soil fertility and controlling pests has provided the American consumer with a wide variety of high quality, low cost foods. While the importance of these chemicals in our society is undeniable, we are just beginning to recognize the societal costs associated with their widespread use. Until very recently, little was known regarding the fate and transport of agricultural chemicals in the environment. However, discoveries of chemical residues in groundwater during the late 1970s and early 1980s dispelled the commonly held view that groundwater was protected from agricultural chemicals. In a recent status report on the occurrence of pesticides in the nation's groundwater, the U.S. Environmental Protection Agency (EPA) confirmed that residues from 46 pesticides have been detected in 25 states and that these residues could be attributed solely to normal agricultural use.

These recent findings have raised considerable concern among the public, government officials, and the agricultural community about the risks agri-chemicals may pose to human health. While there is still a great deal of uncertainty regarding the actual extent of groundwater contamination and the long-term health effects associated with chronic exposure to these chemicals, many view agriculture as a major source of the problem. Regulation is one policy mechanism which can be used to address this issue. Regulatory decisions that focus on the use of pesticides are typically the authority of the EPA, though several states have recently begun restricting the use of certain chemicals which are found to be a local problem. However, the regulatory process does not completely consider the economic and environmental implications. These impacts often reflect the site-specific nature of groundwater quality problems and emphasize the importance of targeting restrictions to those areas most susceptible to environmental damage.

The focus of our paper is to examine the economic and environmental trade-offs which may result from policies restricting the use of selected pesticides in the U.S. We will utilize the results of assessments of changes in crop yields and production costs made at the Economic Research Service and the Potential Pesticide Leaching Algorithm (PPLA) to determine efficiency gains from targeting selected pesticide use restrictions to environmentally sensitive areas, rather than a complete national ban. Pesticides to be restricted are the ones that have been detected in groundwater and are of most concern at present. It has been noted that these pesticides are predominantly applied to corn and soybeans. PPLA facilitates regional assessment of the effectiveness of various policy proposals in reducing the risk of groundwater degradation. The model estimates the potential for leaching which arises from the use of pesticides on the major commodities: corn, sorghum, wheat, barley, oats, cotton, rice, peanuts, tobacco, soybeans, and hay. The model is capable of estimating changes in leaching potential which may result from 1) regional shifts in crop production, 2) changes in the intensity of pesticide use, and 3) removal of certain land or soil groups from production within a region.

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Session H -- Environmental Assessments and Wildlife

Moderator: Bruce Julian, State Resource Conservationist, U.S.D.A. Soil Conservation Service, Richmond

A Test of Avoidance of Herbicides and Changes in Kidney and Liver Weights in *Peromyscus leucopus*
J.P. Sullivan*, Department of Fisheries and Wildlife Science, Virginia Polytechnic Institute and State University, Blacksburg; E.R. Stinson, Virginia Department of Game and Inland Fisheries, Blacksburg; P.F. Scanlon, Department of Fisheries and Wildlife Science, Virginia Polytechnic Institute and State University

Assessment of a New Jersey Lake Contaminated with Fenamiphos
L.W. Meyer* and D. Russell, Pesticide Control Program, New Jersey Department of Environmental Protection; J.B. Louis, L. Jowa, G. Post, and P. Sanders, Division of Science and Research, New Jersey Department of Environmental Protection, Trenton

Pesticide-Related Wildlife Mortality in Virginia, 1980 - 1990
E.R. Stinson*, Virginia Department of Game and Inland Fisheries, Blacksburg

DDT and Its Metabolites' Residues and Persistence in California Wetlands and Their Effects on Migratory Bird Management in the Pacific Flyway
J.C. Wolfe*, U.S. Fish and Wildlife Service, Portland, Oregon; S. Goodbred, U.S. Fish and Wildlife Service, Laguna Nigel, California; W. Henry, U.S. Fish and Wildlife Service, Fallon, Nevada

The Potential Threat of Pesticides on the Lake Kinneret (Israel) Ecosystem
D. Wynne*, Israel Oceanographic & Limnological Research Co., The Yigal Alon Kinneret Limnological Laboratory, Tiberias, Israel

A Test of Avoidance of Herbicides and Changes in Kidney and Liver Weights in *Peromyscus leucopus*

J.P. Sullivan[1], E.R. Stinson[2] and P.F. Scanlon[3]

Two experiments were performed to test whether white-footed mice *(Peromyscus leucopus)* are able to detect glyphosate or atrazine, and what effects these herbicides have on liver, kidney, and whole body weights. In experiment 1, which lasted 10 days, mice were provided with choices of ground rodent chow treated with no herbicide and 1X field application rate (FAR) or no herbicide and 4X FAR. Controls were provided with untreated food only. In experiment 2, which lasted 28 days, mice were provided with food treated with no herbicide, 1X FAR, or 4X FAR. When given a choice, mice were able to detect and avoid atrazine but did not avoid glyphosate. Only the male control mice for glyphosate from experiment 1 lost a significant amount of weight. During experiment 2, when only one food choice was given, no differences were found for food consumption in the different treatment groups. We observed no significant differences for absolute or relative kidney or liver weights among the dose groups for either atrazine or glyphosate. No significant changes in body weights were observed for any dose group.

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Assessment of a New Jersey Lake Contaminated with Fenamiphos

**L.W. Meyer[1], D. Russell, J.B. Louis[2],
L. Jowa[2], G. Post[2] and P. Sanders[2]**

In July 1989, a fish kill was reported in a lake located on a Boy Scout camp in Camden County, New Jersey. Investigations conducted by the New Jersey Department of Environmental Protection (NJDEP) indicated that an application of *Nemacur*^{R} (active ingredient fenamiphos) to a nearby golf course prior to heavy rainfall was the likely cause of the kill. The pesticide entered into the waterway system that originates at a lake at the Pine Valley Golf Club. The water from this lake feeds into three interconnecting lakes, finally emptying into the Cooper River. The first two of the four lakes in the system suffered massive fish kills as a result of the application. Soil and water samples were obtained on the golf course, as well as water samples from the three downstream lakes. Since the three downstream lakes are used for swimming, boating, and other recreational activities, NJDEP Division of Science and Research's Environmental Exposure and Risk Assessment Units became involved in the investigation and monitoring operations. A risk assessment was developed, using the fenamiphos Health Advisor (Office of Drinking Water, USEPA) and assumptions regarding dermal absorption from water, to provide a concentration of fenamiphos at which swimming was safe. This information was provided to the Camden County Health Department as an aid in assessing the levels of the pesticide relative to human health. Another assessment was also performed which determined the allowable concentration of fenamiphos in the water for continued use of a water slide at a local amusement park. In addition, a series of estimates of the environmental fate of fenamiphos was developed using the EXAMS (Exposure Analysis Modeling System) computer model. These estimates provided a guide for estimating the dissipation of the pesticide in the lakes affected and helped direct the location and timing of additional monitoring efforts. Monitoring activities continued until the levels of fenamiphos were reduced below levels determined to pose potential health risks.

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Pesticide-Related Wildlife Mortality in Virginia
1980 - 1990

E.R. Stinson[1]

The Virginia Department of Game and Inland Fisheries (VDGIF) documented 15 confirmed pesticide-related kills of terrestrial wildlife in Virginia between July 1980 and May 1990. The majority of these kills involved birds, and the number of animals involved in any one incident exceeded 200 individuals. Carbofuran, a carbamate insecticide and nematocide, was established as the poisoning agent in seven of the 15 incidents. Other pesticides confirmed as poisoning agents include the organophosphate insecticides diazinon and parathion, the organochlorine insecticide dieldrin, and the rodenticide warfarin. Species killed included northern bobwhite, American goldfinch, red-tailed hawk, American robin, chipping sparrow, common grackle, brown-headed cowbird, European starling, Canada goose, red-winged blackbird, rock dove, bald eagle, eastern bluebird, purple martin, northern cardinal, and barn swallow. Numerous suspected but unconfirmed cases of pesticide poisonings of wildlife also have been documented in the Commonwealth.

Approximately 300,000 ha of Virginia farmland were treated with over 500,000 kg of insecticides and nematocides in 1986. Given the extensive area on which these pesticides are applied, one might suspect significant impacts on wildlife. However, the number of documented kills does not support this hypothesis. An examination of the circumstances and species recovered in documented kills suggests that the number of pesticide-related wildlife kills in Virginia is underestimated. Pesticide-related bird kill reports in Virginia have been biased in favor of those kills involving a) large, highly visible birds, b) relatively large numbers of birds, and c) small numbers of birds discovered in homeowners' yards.

Detected but unreported kills and undetected kills probably contribute to reporting bias and the low number of reported kills in the Commonwealth. Observed wildlife kills may go unreported due to fear of liability on the part of the pesticide applicator or landowner, an observer's lack of awareness of the importance of reporting kills, or the absence of an obvious connection between pesticides and dead wildlife. Kills may go easily undetected for numerous reasons, including the small size, cryptic coloring, and behavior of affected animals, removal of carcasses from a kill site by scavengers, rapid decomposition of small animals, and the remoteness of areas where kills are likely to occur.

Knowledge of pesticide-related wildlife kills and information about the chemical agents responsible for wildlife deaths are vital for accurate assessment of the costs and benefits of using particular pesticides in the Commonwealth. Such information also is used by the Environmental Protection Agency during special reviews of pesticides. The VDGIF and the Virginia Cooperative Extension Service have recently expanded their efforts to increase public awareness of the potential effects of pesticides on wildlife and the importance of reporting pesticide-related wildlife kills. Existing information about pesticide-related wildlife kills in Virginia is currently scattered among several state and federal agencies, universities, and private wildlife centers in the Commonwealth. There is a pressing need for a comprehensive reporting system and increased cooperation between interested parties to consolidate and disseminate information.

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DDT and Its Metabolites' Residues and Persistence in California Wetlands and Their Effects on Migratory Bird Management in the Pacific Flyway

J.C. Wolfe[1], S. Goodbred[2], and W. Henry[3]

Based on reconnaissance and detailed investigations at national wildlife refuges associated with heavily irrigated wetlands in California and Nevada, it appears that the presence of DDT and its metabolites are persisting for longer periods of time and in higher than expected levels. This is shown in the analyses of residues in sediment and tissue samples of key species and their associated prey species for sites in the Sacramento, San Joaquin, Coachella, and Imperial Valleys in California and the Lahontan Valley in Nevada. Other investigations suggest that this situation may be also occurring in southeast Oregon, eastern Washington, and western Idaho and Arizona.

Recent soil studies by the Environmental Protection Agency have shown that the half life of DDT and its metabolites is not seven years but maybe closer to 30+ years under conditions of high clay fractions with limited redox potential and associated with heavily irrigated agricultural operations. The study sites evaluated by the U.S. Fish and Wildlife Service (USFWS) receive surface and ground water flows from such sources. The effects of these levels of chemical exposure and its influences on management decisions are discussed. Potential remediation measures are evaluated. Management decisions already taken and being evaluated for USFWS lands and programs are reviewed.

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The Potential Threat of Pesticides on the Lake Kinneret (Israel) Ecosystem

D. Wynne[1]

The watershed of Lake Kinneret (the Biblical Sea of Galilee) is the site of intensive agriculture. Cotton is the main crop, and large quantities of pesticides are used in the region. These chemicals, or their breakdown products, may therefore reach the lake, either dispersed in water or bound to soil or sediment particles. Currently, the Kinneret supplies about one third of Israel's total water requirements, but both the absolute amount and the proportion used for domestic purposes are expected to rise in the future. Furthermore, the lake possesses several finely balanced food chains, disruption of which could lead to a rapid deterioration in water quality. Monitoring and prevention of pesticide pollution is therefore of prime importance to effective water management.

In order to evaluate the potential threat of toxic agricultural chemicals on the Kinneret ecosystem, a monitoring program for the detection of pesticide residues in water, sediment, and the biota was begun in 1979. This involved the extraction of samples with a suitable organic solvent, concentration (and clean-up, if necessary) of the extract, and analysis for pesticide residues by gas chromatography. Since the inception of this program, however, the spectrum of pesticides used in the Kinneret watershed has diversified tremendously. There has been a tendency away from environmentally persistent pesticides (such as organochlorinated compounds) to those which are more rapidly degraded in aquatic systems (i.e., organophosphorus and carbamate compounds). In addition, an increase in the use of the synthetic pyrethroid insecticides in the Kinneret water catchment area has been noted in recent years. Moreover, economic and other reasons have lead to a reduction in the quantities of pesticides used in this area. Because of all these factors, the analyses of pesticide residues in the Kinneret ecosystem is now much more complex than at the beginning of this program.

The results obtained in the first 10 years of this on-going study can be summarized as follows:

(a) Pesticide residues in Kinneret water were generally below detectable levels. Routine monitoring was therefore concentrated in the upper reaches of the Jordan River, close to pesticide application sites,

(b) Initially, many samples of water and fish were heavily contaminated with pesticide residues, but over the last few years levels of these chemicals have dropped sharply.

The apparent decline in detectable pesticide concentrations in the Kinneret ecosystem should not, however, be viewed with complacency. Changes in the concentration and types of pesticides noted above illustrate the need for a dynamic monitoring program (i.e., one that can adapt to a variety of concentrations and/or compounds, and yet be also suitable for the detection of one-time pollution events). In addition, the data suggest that biological aspects of pesticide pollution (such as the influence of sublethal concentrations on components of the Kinneret ecosystem) will become more important in the future.

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Session I -- Risk Analysis and Strategies for Predicting and Reducing Pesticides in Ground and Surface Water

Moderator: *R. Gene Gilbert,* National Agricultural Chemical Specialist, Ecological Sciences Division, Soil Conservation Services, Washington, D.C.

Interpretation of Atrazine in Ground Water Data Using a Geographic Information System
K. Balu*, CIBA - GEIGY Corporation, Greensboro, North Carolina; R.T. Paulsen, The Paulsen Group, Northport, New York

Reduced Herbicide Application Strategies to Minimize Groundwater Contamination in Sandy, Coarse-Textured Soils
T.J. Bicki*, Department of Agronomy, L.M. Wax, USDA-ARS, and S.K. Sipp, Department of Agronomy, University of Illinois, Urbana

The SCS/ARS/CES Pesticide Properties Database: Combining it with Soils Property Data for First-Tier Comparative Water Pollution Risk Analysis
D.W. Goss*, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Texas; A.G. Hornsby, IFAS, University of Florida CES, Gainesville; R.D. Wauchope, Agricultural Research Service, U.S. Department of Agriculture, Tifton, Georgia

The SCS/ARS/CES Pesticide Properties Database: A Set of Values for First-Tier Comparative Water Pollution Risk Analysis
R.D. Wauchope*, Agricultural Research Service, U.S. Department of Agriculture, Tifton, Georgia; A.G. Hornsby, IFAS, University of Florida CES, Gainesville; D.W. Goss, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Texas; J.P. Burt, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Application of Risk Screening Techniques to Twelve Pesticides Used in Maryland
R.B. Kroll*, D.L. Murphy, and M.J. Garreis, Maryland Department of the Environment, Water Management Administration, Baltimore

Interpretation of Atrazine in Ground Water Data Using A Geographic Information System

K. Balu[1] and R.T. Paulsen[2]

Interpretation of the results from 12,172 nationwide groundwater samples for atrazine, the most commonly used herbicide in the United States has been performed using readily available data base management and mapping software. The interpretation of these data has been requested by the U.S. Environmental Protection Agency as part of a Data-Call-In for atrazine. Two commonly available software packages: dBase III+ for data base management and MAPINFO a menu driven mapping system were run on a Dell 220, VGA Colorplus desktop computing system. The results of the interpretation suggest that 1) the presence of atrazine above the 3 ppb health advisory generally correlates with point sources, 2) on a nationwide scale there appears to be no correlation between the presence of nitrate above 10 ppm and the presence of atrazine, 3) the relative contribution of the following four pathways of transport to groundwater—point sources, direct conduits, induced surface water infiltration into aquifers, and field leaching—vary with geographic location across the nation, and 4) there is no correlation between the occurrence of atrazine in groundwater and DRASTIC (United States Environmental Protection Agency's Aquifer Sensitivity Ranking System) values exceeding 140. This data base/mapping system, Atrazine Cartographic Evaluation System (ACES), is an affordable, relatively user friendly, and powerful tool for the interpretation of atrazine in groundwater data.

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Reduced Herbicide Application Strategies to Minimize Groundwater Contamination in Sandy, Coarse-Textured Soils

T.J. Bicki[1], L.M. Wax[2], and S.K. Sipp[3]

This study evaluated the banding of herbicides in conjunction with cultivation as a management practice to reduce herbicide application rates. Field experiments were established at the University of Illinois Irrigated Research Farm at Kilbourne, Illinois on a Bloomfield sand (Psammentic Hapludalf). Rotational corn and soybean plots were established on adjacent areas and each received four treatments: 1) a full-rate, broadcast application (B), 2) a 20 cm (8 in) band application followed by cultivation (BC1), 3) a 20 cm (8 in) band application followed by two cultivations (BC2), and 4) cultivation followed by a broadcast post-emergence herbicide application (CP). Corn grain yields, averaged over three years, were not significantly different (LSD at the 0.05 confidence level) for the four treatments and ranged from 119.5 to 124.2 bushels/acre. Significant differences in corn yield were detected for some treatments in two of the years. Soybean yields, averaged over three years were not significantly different (LSD at the 0.05 confidence level) for the four treatments and ranged from 36.0 to 37.8 bushels per acre. Soybean yields for the four treatments in individual years were also not significantly different. Weed control ratings were not significantly different for the four treatments over the three years of the study. Band application of herbicides resulted in a 73 percent decrease in amount (mass) of active ingredient applied to soil. Production costs for the various treatments varied depending upon the compounds selected for use and their cost. Using current herbicide prices and rates of application, broadcast treatments were $35.80/hectare ($14.50/acre) for corn (alachlor + atrazine) and $66.69/hectare ($27.00/acre) for soybeans (alachlor + chloramben). Band application costs for the BC1 and BC2 treatments amounted to $9.67/hectare (3.92/acre) for corn and $18.00/hectare ($7.29/acre) for soybeans. Cultivation costs were $14.82/hectare ($6.00/acre). Total costs (pesticide + cultivation costs) for the BC1 treatments were $24.49/hectare ($9.92/acre) for corn and $32.82/hectare ($13.29/acre) for soybeans. Total costs for BC2 were $39.31/hectare ($15.92/acre) for corn and $47.67/hectare ($19.29/acre) for soybeans. Overall production costs for the BC1 treatment represented a 31.5 percent reduction for corn and a 51 percent reduction for soybeans, respectively, relative to broadcast treatment costs. Overall production costs for the BC2 treatments represent a 9.7 percent increase for corn and a 28.6 percent reduction for soybeans, respectively, relative to the broadcast treatment costs. CP treatment costs were $39.31/hectare ($15.91/acre) for corn (atrazine + tridphane) and $50.48 ($20.43/acre) for soybeans (fluazifop-P). Weed control costs for the CP treatments were 37.5 percent higher for corn and 24.3 percent lower for soybeans relative to broadcast application costs. Banding of herbicides in conjunction with cultivation was found to be a viable, cost-effective, and environmentally sound strategy for reducing herbicide application rates in a sandy soil that has a high potential for pesticide leaching.

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The SCS/ARS/CES Pesticide Properties Database: Combining it With Soils Property Data for First-Tier Comparative Water Pollution Risk Analysis

D.W. Goss[1], A.G. Hornsby[2] and R.D. Wauchope[3]

A new, extensive database of critically selected values for the most basic environmentally relevant physical properties of 200 pesticide active ingredients is available. This database, when combined with soils property data, allows an initial screening to be made for the relative water pollution risk of different pesticides when used in specific agricultural settings. Numeric values of pesticide soil half-life, solubility, and soil sorption coefficient are used to calculate indices of runoff and leaching potentials for each pesticide. Numeric values of soil organic matter content, horizon thickness, erodibility index, and hydrologic soil group are used to calculate an inherent mobility index for individual soils. Combining soil and pesticide indices for a specific pesticide/soil combination results in a relative estimate of risk of leaching/runoff for that combination. GLEAMS model simulations were used over a wide range of pesticide and soil properties to determine classes of risk. Initial experience with the technique, limitations, and improvements will be discussed.

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The SCS/ARS/CES Pesticide Properties Database: A Set of Values for First-Tier Comparative Water Pollution Risk Analysis

R.D. Wauchope[1], A.G. Hornsby[2],
D.W. Goss[3] and J.P. Burt[4]

Knowledge of the numeric values of a specific set of four, or in some cases five, pesticide physical properties can, when combined with soils data, provide a first-approximation estimate of the relative surface and groundwater pollution potential of that pesticide's agricultural use. These properties are vapor pressure, persistence (half-life) in soil, aqueous solubility, soil organic matter adsorption/desorption coefficient, and (if the pesticide is an acid or base) acid or base dissociation equilibrium constant. In a cooperative project between USDA-ARS/SCS/ES, the University of Florida CES, the National Agricultural Chemicals Association, and pesticide manufacturers, a review of literature and manufacturer data for these properties for approximately 200 active ingredients chemicals has been placed in a database and consensus best values selected. Strengths and limitations of the database and of the current risk analysis procedures using it will be reviewed.

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Application of Risk Screening Techniques to Twelve Pesticides Used in Maryland

R.B. Kroll[1], D.L. Murphy, and M.J. Garreis

Risk screening techniques were applied to 12 commonly used pesticides to determine which, if any, should be included in a pilot monitoring program of Maryland's surface waters. The 12 pesticides were alachlor, atrazine, butylate, carbofuran, chlorpyrifos, cyanazine, diflubenzuron, glyphosate, linuron, metolachlor, simazine, and 2,4-D. Scientific data from numerous secondary reference sources, including several computer data bases (U.S. Environmental Protection Agency [USEPA] Information Retrieval Service [IRIS], USEPA Aquatic Information Retrieval [AQUIRE], and the National Library of Medicine Hazardous Substances Data Base [HSDB]), was gathered and sorted into several categories (i.e., environmental fate, aquatic toxicity, bioaccumulation/bioconcentration, and mammalian/human health) and sub-categories (e.g., persistence, mobility/leachability).

With the pool of data gathered, a semi-quantitative screening system was developed. Based on the severity of effect or impact, each pesticide received a "high" (2 stars), "moderate" (1 star), or "low" (no star) rating for each category/sub-category of information. Additional stars could be received if a pesticide was a demonstrated human or animal carcinogen/tumorigen (1 star) or teratogen/mutagen (1 star). If no data for a given category/subcategory were available from searched sources, a data gap was acknowledged, and no rating was determined. If retrieved information was highly variable for a given effect or characteristic, that variability was acknowledged with a range of severity. A pesticide's relative total impact potential was represented as a fraction, with the numerator as the total number of stars received and the denominator as the maximum number of stars that could have been received if each category of data had received a "high" rating. In addition, the total impact potential itself was evaluated to determine whether a given pesticide's relative rating was primarily the result of possible environmental or human health effects. The maximum number of stars a pesticide could receive if there were no data gaps and if the pesticide was rated with high severity of effect in all categories was 12 stars overall.

Based on Maryland Department of Agriculture estimates of use and the relative ratings derived in the screening system, six of the twelve pesticides (alachlor, atrazine, carbofuran, chlorpyrifos, metolachlor, and simazine) were recommended for inclusion in a pilot surface water monitoring program. An additional pesticide, diflubenzuron, also received a relatively high rating from the screening system, but was not recommended for initial monitoring due to its limited use.

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Session J -- Resistance, Residues, and Remediation

Moderator: Elizabeth R. Stinson, Virginia Department of Game and Inland Fisheries, Blacksburg

Pesticide Residues Measured in Fruits and Vegetables

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The Use of Membrane Vesicles as a Tool for Investigating Known and Potential Pesticides

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Remediation of Herbicide Waste in Soil: Experiences with Landfarming and Biostimulation

A.S. Felsot* and E.K. Dzantor, Illinois Natural History Survey, Center for Economic Entomology, Champaign

Genetic Engineering of Plants: An Alternative to Synthetic Pesticides and a New Component of Integrated Pest Management

M.B. Sticklen*, Michigan State University, Plant Tissue Culture and Genetic Engineering Laboratory, East Lansing

Pesticide Residues Measured in Fruits and Vegetables

J.B. Louis[1], G. Post, M.G. Robson[2],
G.C. Mattern[3], Chao-Hong Liu, and J.D. Rosen

Recently, attention has focused on the potential health effects of pesticide residues in food. The data currently available on the concentrations of pesticides in the food supply is limited for certain pesticides. For these reasons, a survey of pesticide residues in nine major fruit and vegetable crops was conducted. The crops were chosen based upon their economic importance to New Jersey. A total of 25 samples each of apples, lettuce, peaches, peppers, potatoes, snap beans, spinach, sweet corn, and tomatoes were collected. Approximately half of the samples came from foreign countries or were grown in other states. These samples were collected at major supermarket distributors in New Jersey. The remaining samples consisted of fresh produce grown in New Jersey and collected at New Jersey farms. A total of 20 target pesticide residues were chosen for analysis based upon their use on these crops, persistence in plant tissue, potential chronic health effects, and lack of monitoring data from other sources. The EPA has designated 13 of the target pesticides as possible or probable carcinogens. Some of the pesticides included in the analyses were alachlor, benomyl, daminozide, captan, and chlorothalonil. Pesticides were extracted from the food matrix using a modification of the Luke method. The pesticide analysis was carried out using either GC/MS or HPLC/MS methods. In addition, the FDA laboratories in Buffalo or Baltimore analyzed duplicate farm gate samples using their standard GC methods for pesticide analysis. In no cases were residues of pesticides or metabolites detected at levels above the established EPA food tolerances. Residues were most frequently detected in peaches, and none of the target pesticides were detected in potatoes and sweet corn. Details of the results of this two-year study will be presented.

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The Use of Membrane Vesicles as a Tool for Investigating Known and Potential Pesticides

M. Reuveni[1] and P.E. Dunn

Insects which are pests derive this status as a result of their feeding activity. However, mechanisms of insect midgut function and the pathways for uptake of nutrients, such as amino acids and sugars in the midgut, have not been studied extensively. Attempts to develop new applications of bacterial toxins such as the delta-endotoxins from *Bacillus thuringiensis*, for insect management have focused attention on the importance of understanding insect midgut function.

Membrane vesicles can be used for studying two aspects of pesticide activity/toxicity. The first is to accumulate basic data to identify potential targets for the development of new species specific and safe insecticides. The second is to study the mechanism and mode of action of existing pesticides acting on the midgut epithelium. Brush border membrane vesicles (BBMV) are also a useful tool in the study of insect resistance to certain types of pesticides, for example the development of resistance to the delta-endotoxins produced by *Bacillus thuringiensis* (*Bt* toxin).

The interaction of *Bacillus thuringiensis* HD73 toxin (CryIa) with BBMV is used as a model system for studying the above objectives. It seems that the membranous receptor for the toxin may be a specific amino acid transport system. Preincubation of BBMV with *Bt* toxin caused the preferential inhibition of leucine transport into these membrane vesicles.

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Remediation of Herbicide Waste in Soil: Experiences with Landfarming and Biostimulation

A.S. Felsot[1] and E.K. Dzantor

The utility of landfarming for detoxifying pesticide waste in soil was examined at an agrochemical facility in Piatt Co., Illinois. Soil contaminated with the herbicides alachlor, atrazine, metolachlor, and trifluralin was excavated, and various amounts were applied to an adjacent field divided into corn and soybean plots. Dissipation of residues, phytotoxicity to crops and weeds, bioaccumulation in grain, and quality of shallow groundwater were monitored after application of the contaminated soil. Data from soil-treated subplots were compared to data from subplots in which herbicides were freshly sprayed. Herbicides did not dissipate significantly in excavated soil that had been stockpiled on the ground. Microbial assays of the contaminated soil showed low bacterial populations and inhibited soil dehydrogenase. After two years, alachlor and metolachlor concentrations in soil-treated subplots were significantly higher than concentrations in freshly-sprayed subplots. Some phytotoxicity to soybeans was noted from the heaviest loadings of waste soil, but freshly applied herbicides caused significantly more damage. Greenhouse bioassays of diluted waste soil showed little phytotoxicity to corn or soybeans; however, bioactivity against weed species was high. Residues of parent herbicides did not bioaccumulate in grain, and herbicide levels in shallow groundwater were not affected by soil treatment. Potential problems with land application of herbicide waste included prolonged persistence of herbicide residues in soil and crop phytotoxicity when a diverse mixture of herbicides are present.

To improve the capability of landfarming for remediating pesticide waste in soil, a series of laboratory experiments were conducted to better characterize the degradation of high concentrations of acetanilide herbicides and to determine if degradation could be enhanced by biostimulation or bioaugmentation. Spills of alachlor were simulated in soil under laboratory conditions; concentrations of 1,000 ppm or 10,000 ppm did not degrade after two months or one year of incubation, respectively. In contrast, 10 ppm and 100 ppm doses of alachlor were degraded partially into water-soluble metabolites. Technical-grade alachlor and an emulsifiable concentrate formulation were metabolized similarly. Microbial populations and dehydrogenase activity in soil were reduced upon exposure to 1,000 ppm or 10,000 ppm alachlor, and lack of degradation of these high concentrations was attributed to microbial toxicity from alachlor itself rather than additives in its formulation. Amendment of soils with ground corn or soybean stubble enhanced the detoxification of alachlor at a concentration of 100 ppm but not at 1,000 ppm. Aged soil from the simulated spill of 10,000 ppm alachlor was diluted with uncontaminated soil to yield a concentration of 100 ppm alachlor. With the addition of corn residues, aged alachlor degraded as quickly as an equal concentration of freshly applied herbicide. Alachlor in aged, contaminated soil taken from an agrochemical facility, however, degraded more slowly than comparable levels of freshly applied alachlor. Inoculation of soil with a *Fursarium* sp. isolate that could cometabolically degrade alachlor in pure culture, temporarily enhanced the biodegradation of a 100 ppm dose of alachlor.

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Genetic Engineering of Plants: An Alternative to Synthetic Pesticides and a New Component of Integrated Pest Management

M.B. Sticklen[1]

Broad successes have been achieved in controlling pests through the efforts of the agrichemical industries, plant breeders, and scientists developing integrated pest management programs. But despite those successes, it is estimated that one third of global agricultural production is lost annually to over 20,000 species of agricultural pests. In pure economic terms, this loss is valued at over one billion dollars.

During the millions of years of plant-pest co-evolution, many plants have developed resistance against pests. Among plant species studied, over 3,000 (M. Grainge and S. Ahmed, 1988, John Wiley & Sons Inc.) have developed genetic systems for pest resistance. Certain plants have even developed genes which can turn on the pest defense genes of neighboring plants. Today's research on identification and isolation of these genes and their transfer into the genome of economically important crop species will become tomorrow's common practice. The future of plant genetic engineering as an alternative to pesticides and a part of integrated pest management holds promises of more productive crop species. Pests can develop resistance against the foreign gene products, probably in the same fashion that they are developing resistance against pesticides. Thus, the overall enterprise of engineering the pest resistance genes into plants can best be described as an effort toward keeping ahead in the battle against the adaptive pests.

In this talk, I shall discuss the genetic engineering of plants for pest resistance and the strategies which could be considered to slow or prevent the development of resistance to the gene products by pests.

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Session K – Pesticide Registration and Field Assessments

Moderator: Jean Gregory, Environmental Program Manager, Office of Environmental Research and Standards, Virginia Water Control Board, Richmond

The Dissipation of Triclopyr in Lake Seminole, Georgia, Following an Aquatic Herbicide Application
P.L. Burch*, DowElanco, Raleigh, North Carolina; H.E. Westerdahl, Batelle Northwest, Richlands, Washington; K.B. Woodburn, DowElanco, Midland, Michigan; J.L. Troth, DowElanco, Indianapolis, Indiana

Dispersal and Degradation of Triclopyr Within a Boreal Forest Ecosystem Following an Aerial Application of GARLON 4* Herbicide
J.L. Troth*, DowElanco, Indianapolis, Indiana; D.D. Fontaine, DowElanco, Midland, Michigan; T.S. MacKay, DowElanco Canada, Inc., Etobicoke, Ontario; D.G. Thompson, Forest Pest Management Institute, Sault Ste. Marie, Ontario, Canada; G.R. Oliver, DowElanco, Indianapolis, Indiana

Quantitation of Nonpoint Source Pollution with Diazinon and Carbaryl
K.H. Deubert*, University of Massachusetts, Cranberry Experiment Station, East Wareham

Environmental Assessments of Agricultural Lands
A.J. Gordon* and K. Richardson, SCS Engineers, Reston, Virginia; B.F. Johnston, SCS Engineers, Phoenix, Arizona

The Dissipation of Triclopyr in Lake Seminole, Georgia, Following An Aquatic Herbicide Application

P.L. Burch[1], H.E. Westerdahl[2],
K.B. Woodburn[3] and J.L. Troth[4]

A study of the aquatic dissipation of triclopyr was conducted at Lake Seminole, Georgia, from July to August 1986, following application of the maximum aquatic-use rate of 2.5 mg (triclopyr) per L of water. At 31°N latitude during mid-summer and a water temperature of approximately 30°C, triclopyr in water had an average first-order half-life of 0.5-3 days; the observed degradation kinetics in water were consistent with the rate of aqueous photolysis of triclopyr as measured in prior laboratory studies. The intermediate metabolite of triclopyr, 3,5,6-trichloro-2-pyridinol (TCP), had an observed half-life in water of less than one day. No accumulation of triclopyr or TCP on sediment was observed. The first-order half-life of triclopyr in aquatic plants averaged 3.2 days. Neither bottom-feeding nor sport fish species exhibited any bioconcentration of triclopyr or TCP during the study period. Only trace amounts of either compound were detected in whole fish tissue at any time in the study. The observed first-order half-life of triclopyr in whole crayfish averaged 8 days, while an approximate 2 day half-life was observed in edible clam tissue. Water quality data (DO, conductivity, temperature, pH) were collected throughout the study period, and there was no apparent decline in water quality in any treatment plot. In summary, triclopyr and TCP appear to undergo rapid dissipation in the aquatic environment without adverse effects on the aquatic system. These results are consistent with the observed environmental chemistry of triclopyr and TCP.

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Dispersal and Degradation of Triclopyr Within a Boreal Forest Ecosystem Following an Aerial Application of GARLON 4* Herbicide

**J.L. Troth[1], D.D. Fontaine[2], T.S. Mackay[3],
D.G. Thompson[4] and G.R. Oliver[5]**

In August, 1987, a 90-ha forest site near Hearst, Ontario, was treated with triclopyr butoxyethyl ester herbicide at a nominal rate of 3.8 kg a.i. per ha. Application included an intentional overspray of Dora Creek to permit monitoring of residues which might be introduced into streamwater by an applicator error. The dissipation half-life of triclopyr in soil and litter layers averaged 29 days during summer and autumn prior to winter freezing and did not differ significantly among plots within the treated area ($p > 0.05$). The half-life for conversion of triclopyr ester to acid in streamwater was 3 to 6 hours and continued in the dark. Streamwater at the downstream edge of the treated area contained no quantifiable residues of triclopyr after day 1 following treatment. A pulse of triclopyr residues was observed in streamwater during a 41-mm rainfall event that occurred on day 1. Quantifiable residues were not detected in streamwater during subsequent rainfalls. Only one sediment sample contained triclopyr residues after day 3. The concentration of triclopyr in stream sediments was typically less than 0.05 ppm. The half-life for dissipation in aquatic plants was 7 days or less. These results reinforced the previously observed environmental chemistry of triclopyr.

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Quantitation of Nonpoint Source Pollution with Diazinon and Carbaryl

K.H. Deubert[1]

Diazinon and carbaryl are essential in cranberry production. Both compounds are applied primarily in June and July; consequently, the highest average levels in drainage were detectable early in July. In a river receiving drainage from an approximately 2,500 acre cranberry bog and draining into the ocean, the highest levels were observed 2-3 weeks later. In September when drainage from bogs was reduced as part of bog management, residue levels were lowest. They temporarily increased after harvest in October.

In lab tests using drainage contaminated in the field, both diazinon and carbaryl residues were reduced to 10-20 percent of the initial amounts after 96 hours. In water sterilized with formalin, residues remained steady during 72 hours.

Residue amounts were not in agreement with suspended solids. A living-filter arrangement in the field did not bring about reductions in residue levels although there were reductions in P_T and P_R levels.

Based on ecotoxicological assessment criteria, only drainage contaminated during an application and retained on the bog may be considered hazardous to aquatic organisms for certain periods of time.

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Environmental Assessments of Agricultural Lands

A.J. Gordon[1], K. Richardson and B.F. Johnston[2]

With the expansion of metropolitan areas nationwide, lands previously used for agriculture are being developed for residential and commercial purposes. An increasing number of environmental site assessments performed over the past several years have indicated that formerly active and currently active agricultural properties are both real and potential sources of pesticide contamination in soils.

Environmental assessments of agricultural lands should be conducted by an individual familiar with operational procedures unique to the agricultural industry. Specific current and historical site uses may be evaluated by identifying pesticide storage and handling facilities, as well as container disposal areas. Information pertaining to the types, amounts, and locations of pesticides used may be obtained through interviews with the operators, review of regulatory records, and extrapolation of specific pesticide use that is based on the specific types of crops serviced. The resultant identification of areas and chemicals of potential concern may then indicate the need for soil sampling.

In evaluating current and former agricultural lands, the potential presence of pesticide residues must be addressed. It has been our experience that proposed land use will usually dictate the extent of sampling and laboratory analysis performed, with proposed residential and related uses usually necessitating the most stringent characterization of pesticide residues in soils.

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Session L -- Pesticide Characteristics, Persistence, and Nontarget Effects

Moderator: Harry H. Gregori, Jr., Director, Office of Policy and Planning, Virginia Department of Waste Management, Richmond

Volatilization, Off-site Deposition, Dissipation, and Leaching of DCPA in the Field
L.J. Ross* and S. Nicosia, California Department of Food & Agriculture, Sacramento; M.M. McChesney, Department of Environmental Toxicology, University of California, Davis; K.L. Hefner, and D.A. Gonzalez, California Department of Food & Agriculture, Sacramento; J.N. Seiber and

The Influence of Climatic Variation on Pesticide Fate Predictions
B.R. Cuaresma Lobbe*, J.F. Dowd, and P.B. Bush, School of Forest Resources, University of Georgia, Athens

A Review of Methods for Assessing the Sensitivity of Aquifers to Pesticide Contamination
Jane G. Marshall*, U.S. EPA, Office of Groundwater Protection, Washington, D.C.

The Influence of Dormant Spray Oil on Diazinon Mass Deposition and Transfer to Nontarget Vegetation
B. Turner*, S. Powell, D. Gonzalez, C. Ando, and N. Miller, California Department of Food and Agriculture, Environmental Hazards Assessment Program, Sacramento

Volatilization, Off-site Deposition, Dissipation, and Leaching of DCPA in The Field

L.J. Ross,[1] S. Nicosia[2], M.M. McCheseny[3],
K.L. Hefner,[2] D.A. Gonzalez[2], and J.N. Seiber[3]

Residues of dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA) have been found repeatedly in recent years on a variety of produce grown in California to which this herbicide had not been applied. In response to this problem, drift, volatilization, and dissipation of DCPA were investigated in a circular plot seeded with bunch onions *(Allium cepa* (L.) var. white lisbon), and off-site deposition was measured in a surrounding area seeded with parsley *(Petroselinum crispum* (Mill.) Mansf. var. green modified curl leaf). Contamination by residual soil residues remaining on the field after harvest was also examined by re-seeding the circular plot with parsley. Atmospheric residues detected downwind on resin and filters indicated DCPA moved off-target as a vapor as well as on particles both during and up to 21 days after application. Volatilization flux, measured using the aerodynamic method, reached a maximum rate of 5.6 g ha^{-1} h^{-1}. An estimated 10% of the DCPA applied was lost to the atmosphere by volatilization within 21 days of application. Deposition of DCPA outside the circular plot was evidenced by residues found on potted parsley plants and soil set out up to 23 m from the treated area. Parsley, seeded around the circular plot at the time of application and sampled 63 days later, contained residues ranging from 51 to 250 μg kg^{-1}, indicating DCPA continued to move off-target in air up to two months after application. The mass of DCPA in soil exhibited a log-linear decline from which a 50 day half-life was calculated. Leaching of DCPA was minimal with residues found 122 cm deep at 21 days after application, but was not found below the soil surface 168 and 336 days after application. Parsley planted in the circular plot after the onion harvest did not contain DCPA residues when sample 217 and 336 days after the original application. Results indicated that drift during application and volatilization and subsequent atmospheric transport after application are potentially important sources of DCPA contamination occurring on non-target crops in California.

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The Influence of Climatic Variation on Pesticide Fate Predictions

B.R. Cuaresma Lobbe[1], J.F. Dowd, and P.B. Bush

Field studies of pesticide fate are dependent upon the climatic conditions that occurred during the period of the study. Drought or excessive rainfall conditions could seriously affect field results. This study reports on a model evaluation of the influence of climatic variation on a field experiment.

Lindane was sprayed on a 1.2 hectare loblolly pine *(Pinus taeda)* stand in May 1987. Climatic and hydrologic variables monitored included precipitation, air temperature, soil moisture, soil suction, and stream flow from a nearby perennial stream. Lindane concentrations were collected in stemflow, litter flow, soil water, the water table aquifer, and stream flow.

The Pesticide Root Zone Model (PRZM) was calibrated for the site, and the simulated lindane movement compared to actual concentrations. Model calibration was assisted by results from a tracer study of bromide and chloride performed in the stand in 1989. The best fit soil and stand descriptions were used for all subsequent simulations.

Pesticide movement in the Piedmont region of the Southeast is strongly controlled by evapotranspiration. In coniferous stands, if the temperature is sufficiently high, transpiration can occur year-round and soil water will be depleted. Soil water movement, hence pesticide movement, can occur only when the soil is sufficiently wet. This is usually only during the winter months, but during warm, dry winters, no recharge may occur. Excessive rainfall during the rest of the year could also result in pesticide movement if the rainfall exceeds the evapotranspiration rate, and the soil becomes sufficiently wet. This study evaluates the effect of these different climatic conditions by using thirty years of weather data to examine a three-year experiment. This is accomplished by repeating the simulation with three years worth of data, lagged by one year, using an arbitrary date so that every simulation had the application on the same day of the simulation. Because all of the simulations have the same time base, the mean, maximum, and minimum concentration versus time since application are shown for the soil water at 30-, 60-, and 120-cm depths. These are compared to the field experiments.

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[1] **Presenter**

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A Review of Methods for Assessing the Sensitivity of Aquifers to Pesticide Contamination

J. Marshall[1]

In 1988 the U.S. Environmental Protection Agency (EPA) proposed the Pesticides in Ground-Water Strategy. The strategy encourages decision making at the state and local levels of government, regarding application of pesticides where their use might threaten groundwater quality. As part of this strategy, EPA will promote the development of strong state roles to protect groundwater, including area-specific management of pesticide use.

In response to the Pesticides in Ground-Water Strategy, states will be developing Pesticide Management Plans. The plans provide for management of pesticides based in part on the relative vulnerability (sensitivity) of the underlying aquifer. Some of the state's role may include the following: determining sensitive areas, comparing sensitive areas with agricultural areas and areas of pesticide application, and determining what management controls (including monitoring) will be needed in the sensitive areas.

States will need technical information to help them define the relative sensitivity of their aquifers to pesticide contamination. The EPA Office of Ground-Water Protection is presently engaged in an effort to produce a technical assistance document (TAD) which will present the existing methods of assessing sensitivity of aquifers to pesticide contamination. The methods fall into several categories which may require different technical capabilities and institutional capacity of the state or local groundwater organization responsible for sensitivity assessment. Method categories listed in order of increasing complexity are Hydrogeologic-Setting Comparison, Parameter Weighting, Empirical, and Simulation Models. An overview of method categories with specific examples from the literature and research are provided in this paper.

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The Influence of Dormant Spray Oil on Diazinon Mass Deposition and Transfer to Nontarget Vegetation

B. Turner[1], S. Powell, D. Gonzalez,
C. Ando and N. Miller

In recent studies, the California Department of Food and Agriculture (CDFA) has determined that organophosphate pesticides used in orchard dormant spraying are contaminating nontarget row crops locally and regionally. The inadvertent residues found on nontargeted crops may have been the result of drift during pesticide application or vapor-phase or particulate pesticide transport from branch and soil surfaces after application. CDFA performed a field experiment to determine whether the practice of applying dormant spray oil in conjunction with diazinon affects the mass deposition rate of that pesticide on branch surfaces. An increase in deposition on branch and soil surfaces would have indicated less pesticide drift during an application. Five replicate applications of two treatments consisting of diazinon with and without dormant oil were made to tree-like structures which supported almond branches. Fallout cards placed beneath the structures measured soil deposition and air samples were collected immediately before and after each application. Surrogate branches of filter-paper-covered dowels were treated to compare deposition rates between real and artificial branch surfaces. The results indicated that dormant spray oil had no effect on diazinon mass deposition on branch or soil surfaces.

In a second experiment, the effect of dormant spray oil on the transfer of pesticide from treated surfaces to nontarget vegetation was tested. Ten experimental structures were coated with one of two diazinon treatments (with and without dormant spray oil) and placed around parsley plants. Samples were collected at eight intervals during a 36-day period. Diazinon concentration in parsley increased from day 3 to day 21, then declined. Dormant spray oil had no effect on pesticide concentration over time.

Results of these experiments indicate that dormant spray oil may not be useful in mitigating pesticide drift and transfer to nontarget vegetation.

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[1] **Presenter**

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Session M -- Trends in Pesticide Use and Regulations
Moderator: Donald J. Lott, Regional Pesticide Expert, Toxics and Pesticides Branch, U.S. EPA Region III, Philadelphia

Cotton Pesticide Use and Pest Management
W.L. Ferguson*, Economic Research Service, Resources and Technology Division, Washington, D.C.

The Adoption and Implementation of Integrated Pest Management: Its Effects on the Level of Pesticide Use for California Pear Growers
A.M. Flynn Ridgley* and S.B. Brush, Applied Behavioral Sciences, University of California at Davis

The Use of Herbicides in the United States
L.P. Gianessi* and C.A. Puffer, Resources for the Future, Inc., Washington, D.C.

Trends in the Agricultural Use of Pesticides in New Jersey: 1978 Through 1988
J.B. Louis*, Division of Science and Research, New Jersey Department of Environmental Protection, Trenton; M.G. Robson, Division of Rural Resources, New Jersey Department of Agriculture, Trenton; L.W. Meyer, Pesticide Control Program, New Jersey Department of Environmental Protection, Trenton

The Effect of Increased Pesticide Regulation on the Pest Control Industry in New Jersey
J.J. Pitonyak, Jr.*, L.W. Meyer, and R.C. Smith, Pesticide Control Program, New Jersey Department of Environmental Protection, West Trenton

Spatial Distribution Patterns and the Amount of Pesticides Used in U.S. Crop Production: Current Levels and Projections for 1995 and 2000
L.C. Thompson*, P.G. Lakshminarayan, J. Shogren, and S.R. Johnson, Department of Economics, Center for Agricultural and Rural Development, Iowa State University, Ames; J. Maetzold, USDA Soil Conservation Service, Washington, D.C.

Cotton Pesticide Use and Pest Management

W.L. Ferguson[1]

Relative to many other field crops, cotton production requires both highly intensive and extensive use of chemical pesticides. This paper discusses the extent of current pesticide use and pest management practices by cotton farmers that reduce the need for chemical pesticides. The data, obtained from a 1989 USDA survey, includes the 14 major production states divided into four regions--Southeast, Delta, Southern Plains, and West. The pesticide use and management data include the number of acres treated, treatments, acres under a commercial scouting program, times acreage is inspected, and acres included in specific pest management practices - resistant varieties, stalk destruction, pheromone traps, diapause control, and cultivation.

Of the 10.2 million planted cotton acres in the 14 major producing states, 9.9 million acres or 98 percent were treated with pesticides in 1989. The Southern Plains accounted for nearly one-half of the acreage treated by pesticides, followed by the Delta, West, and Southeast regions. Of the 9.9 million treated acres, 9.4 million were treated with herbicides, 7.4 million with insecticides, 5.5. million with desiccants/defoliants, 3.7 million with growth regulators, and 0.8 million with fungicides.

Pest management practices in cotton are directed toward manipulation of the environment to (a) reduce sources of food and shelter, (b) reduce the rate of pest population increase and damage, and (c) concentrate pest numbers in small areas where direct control measures can be applied with minimum disruption to beneficial species. Surveyed cotton farmers in the 14 states reported 56 percent of their planted acreage in a scouting program, an objective of which was to minimize the use of chemical pesticides by applying chemical controls at the economic threshold level. The number of scouting trips averaged about 18 per acre for the 14 states.

Weed control in cotton is complex, as target weed species may be annuals, biennials, or perennials, with severity of control varying considerably depending on environmental conditions in different regions. The number of acres treated by number of treatments ranges from one treatment on 4.4 million acres to about 630,000 acres using five or more treatments. Major insect pests affecting cotton production include the boll weevil, pink bollworm, bollworm, and tobacco budworm. Surveyed cotton producers in the 14 states reported using insecticides to treat a total of 7.4 million or 73 percent of the 10.2 million planted acres. Fungicides were used on 0.8 million acres or 8 percent of the total 10.2 million planted acres. One treatment of fungicide is generally used. Desiccants and defoliants were used on 5.4 million acres or 54 percent of the total 10.2 million planted acres. Growth regulators were used on 3.7 million acres or 37 percent of the total 10.2 million planted acres.

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The Adoption and Implementation of Integrated Pest Management: Its Effects on The Level of Pesticide Use For California Pear Growers

A.M. Flynn Ridgley[1] and S.B. Brush

The University of California (U.C.) developed and introduced integrated Pest Management (IPM) guidelines and recommendations for California's pear growers in 1978. This study systematically documents the degree of adoption and implementation of these IPM practices by pear producers in Sacramento and Lake counties, the principle pear growing regions in the state.

IPM is considered an approach to pest management using a number of interrelated practices. In order to account for the complexity of adopting an IPM program, in-person interviews were conducted. Over 60% of the pear producers in the two counties were interviewed to collect detailed information on specific components of the pest management strategies of these farmers. The data collected included chemical materials used, rate of application, number of applications, timing of applications, cultural practices, frequency and type of pest monitoring, and decision factors. Factor analysis was used to construct a scale of IPM adoption based upon the U.C. IPM Guidelines.

Individual grower's scores on the adoption scale are compared with level of pesticide use for two primary pests. Significant variation in level of pesticide use is found among growers at the same level of IPM adoption, suggesting that one benefit of IPM may be to assist growers in tailoring pest management programs to their individual needs.

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The Use of Herbicides in the United States

L.P. Gianessi[1] and C.A. Puffer

The use of herbicides for weed control accounts for 60% of the volume of pesticides used annually on U.S. cropland. Resources for the Future, Inc. has assembled a comprehensive national inventory of herbicide usage estimates. Herbicide use is accounted for by crop and state for commonly used active ingredients. The usage pattern of common herbicide active ingredients for agricultural crops are complex. Among the factors that may affect the choice of herbicide for a particular crop are soil type, climate, weather conditions, the presence of a particular weed species, the level of weed infestation, and agricultural practices such as crop rotation and tillage. Consequently, the use of some herbicides can be shown to vary regionally for a particular crop. Certain herbicides are used for weed control on a single crop only, while a few herbicides show some usage on a large number of individual field and horticultural crops. All individual herbicides are used on only a fraction of the cropland for which they are registered for use. The number of individual herbicides available for weed control is greatest for field corn and soybeans. For these, 10-15 different herbicides are used in varying amounts in most states. On the other hand, growers rely on a small number of different herbicides for most vegetable crops. Typically, only one or two herbicides may be used on a particular vegetable crop. Significant reductions in the volume of herbicides used on corn and soybeans are estimated to have occurred since 1984 because of the introduction of new, low-application-rate herbicides. However, herbicide usage on field corn and soybeans still make up a large portion of the total herbicide use nationally.

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Trends in the Agricultural Use of Pesticides in New Jersey: 1978 through 1988

J.B. Louis[1], M.G. Robson[2] and L.W. Meyer[3]

During a ten year period from 1978 through 1988, three surveys of agricultural use of pesticides were conducted in New Jersey. The first was carried out by the New Jersey Department of Health. The data for this 1978 survey was obtained from information collected by agricultural extension agents in each county. The other two surveys were conducted by the Pesticide Control Program (PCP) in the New Jersey Department of Environmental Protection. PCP mailed out survey forms to all certified private applicators (farmers) licensed in New Jersey. Response to these surveys was mandatory and covered agricultural use of pesticides in 1985 and in 1988. New Jersey is a state with a very diverse agricultural sector. It ranks in the top five states in the country in the production of snap beans, cabbage, cranberries, blueberries, and peaches. Altogether, farmers in the state grow 72 vegetables, 10 fruits, and 8 grain commodities. Because of the wide variety of crops grown, information on pesticide use patterns is important to the state in developing programs for the protection of groundwater, the study of pesticide runoff, and monitoring programs for pesticide residues in food. Examples of how these data bases have been used for these applications will be presented. In addition, this set of data bases provides information on pesticide use patterns on fruits and vegetables, a group of commodities that are not generally covered by national pesticide surveys.

The years from 1978 through 1988 saw many changes in pesticide use patterns as additional restrictions were placed on the use of certain pesticides (i.e., aldicarb and alachlor) and the registrations for other pesticides were cancelled (i.e., DBCP, EDB, and 1,2-DCP). The survey data from this time period will be examined to determine the impact of these regulatory actions on pesticide use patterns.

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The Effect of Increased Pesticide Regulation on The Pest Control Industry in New Jersey

J.J. Pitonyak, Jr.[1], L.W. Meyer and R.C. Smith

Over the past decade, the New Jersey Pesticide Control Program, Department of Environmental Protection, has promulgated numerous regulations on the use of pesticides that go far beyond labeling requirements. These regulations include community or area-wide notification, bee-keeper notification, household or structural pest notification, turf or ornamental notification, aquatic use permits, mosquito/fly permits, farm worker safety, termiticide application regulations, and aerial applicator regulations. In addition, registration fees for pesticide products and applicator registrations have increased substantially during this period, and there have been additional pesticide applicator licensing requirements for pet groomers and tributyltin (TBT) applicators. Although New Jersey has placed this increased regulatory burden on the pest control industry, the industry has flourished and increased in the state over this period, indicating that additional regulation of pesticide use is not necessarily restrictive to industry growth.

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Spatial Distribution Patterns and the Amount of Pesticides Used in U.S. Crop Production: Current Levels and Projections for 1995 and 2000

L.C. Thompson[1], P.G. Lakshminarayan,
J. Shogren, S.R. Johnson, and J. Maetzold[2]

Society is concerned with the impact of agrichemical use on the environment. Water quality in particular is vulnerable to pesticide contamination from point and nonpoint sources due to a variety of managerial and biogeophysical factors. Although a national effort is underway to address water contamination, the debate is somewhat stilted by the lack of data on the spatial distribution and magnitude of pesticides used. An assessment of agricultural contributions to environmental degradation with pesticides requires an understanding of which, how much, and where pesticides are being used in crop production. Which pesticides are being used is a function of current and historical pest infestation experience, while regional crop production patterns determine the spatial distribution of pesticides. Lastly, how much pesticide is used is a function of crop production management and technology. However, in the absence of reliable data about the rate and total amounts of pesticide applied to soil surfaces it is difficult to describe the link between agricultural production and environmental quality or assess impacts of programs and policies addressing water quality. This study was conducted to identify the set of chemicals used on a specific crop, tillage, and soil texture and estimate total annual amounts of pesticides used in the United States within an agricultural policy environment reflecting implementation of the conservation titles of the 1985 Food Security Act. Cropland and specific chemical input use, soil erosion levels, and cost of production were estimated for 1990, 1995, and 2000 commodity demand baselines and land resource restrictions for 105 separate crop producing regions of the U.S. An Agricultural Resources Interregional Modeling System (ARIMS) developed at the Center for Agricultural and Rural Development, Iowa State University, was used to estimate land and pesticide inputs used to meet commodity demands for 1990, 1995, and 2000 with current crop production technology. Commodity demands were taken as fixed for the baseline periods while assuming full implementation of 1985 FSA conservation compliance and conservation reserve policy provisions. Crop production possibilities including rain-fed and irrigated production and alternative levels of conservation treatment were specified in the interregional model. The objective function minimized the national cost of production and transportation subject to fixed demands, land availability, technology, and resource use constraints. Assumptions for the 1990, 1995, and 2000 baselines were developed by the 1990 Farm Bill Conservation Work Group which included representation from the U.S. Dept. of Agriculture, U.S. Dept. of Interior, and the Environmental Protection Agency. Results of this study alleviate the information deficiency about what pesticide compounds are being used, where they are used, and the crop production managerial factors that are associated with the flow and intensity of their use. By providing reliable descriptive information about recommended rates and total amounts (lbs of a.i.) of pesticides applied to the soil surface, a foundation exists for evaluating behavioral and economic links between agricultural production decisions and environmental quality. Results were used to assess the impacts of conservation compliance on the magnitude of pesticides used and to discuss implications of conservation reserve cropland being released from the program in the year 2000.

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Session N -- Model Testing and Validation

Moderator: Charles F. Finley, Jr., Executive Vice President, Virginia Forestry Association, Richmond

Using GLEAMS to Estimate Insecticide Movement from an Appalachian Mountain Pine Seed Orchard
L. Crawford*, J.F. Dowd, P.B. Bush, and Y. Berisford, University of Georgia, Athens; D.G. Neary, USDA Forest Service, University of Florida, Gainesville

Pesticide Transport Models: Comparison and Validation with Soil Column Leaching Experiments
T. Harter*, Department of Hydrology and Water Resources, University of Arizona, Tucson; and G. Teutsch, Institut für Wasserbau, University of Stuttgart, West Germany

Validity of Herbicide Prediction Models for Herbicide Movement in the Soil Vadose Zone
D. Penner, Department of Crop and Soil Sciences, Michigan State University, East Lansing; R.D. Shaffer*, USDA-Soil Conservation Service, East Lansing, Michigan

USDA Forest Service Aerial Spray Dispersion Models AGDISP and FSCBG I: Model Formulation
A.J. Bilanin and M.E. Teske*, Continuum Dynamics, Inc., Princeton, New Jersey; J.W. Barry, USDA Forest Service, Forest Pest Management, Davis, California; R.B. Ekblad, USDA Forest Service, Missoula Technology and Development Center, Missoula, Montana

USDA Forest Service Aerial Spray Dispersion Models AGDISP and FSCBG II: Model Validation
A.J. Bilanin and M.E. Teske*, Continuum Dynamics, Inc., Princeton, New Jersey; J.W. Barry, USDA Forest Service, Forest Pest Management, Davis, California; R.B. Ekblad, USDA Forest Service, Missoula Technology and Development Center, Missoula, Montana

Using GLEAMS to Estimate Insecticide Movement from an Appalachian Mountain Pine Seed Orchard

L. Crawford[1], J.F. Dowd, P.B. Bush,
Y. Berisford and D.G. Neary[2]

A field scale model, GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), was used to predict stormflow volume, pesticide residue concentrations, and to evaluate various insect control strategies for seed orchard management in the southern Appalachian Mountains Beech Creek Seed Orchard, Murphy, North Carolina. Site specific GLEAMS computer simulations were compared with onsite runoff and lysimeter data for an operational carbofuran application. After GLEAMS was calibrated to predict carbofuran movement, it was used to 1) evaluate the potential significant insecticide concentrations in an ephemeral stream from operational forest management practices, 2) evaluate a number of insecticide types, application methods, and time of application options, and 3) assist in developing an insecticide monitoring plan. The utility of GLEAMS is in making relative comparisons among options; it is not designed to predict absolute pesticide concentrations. In making quality impact assessments, this model shows potential to be a useful management tool in estimating the relative extent of pesticide runoff from seed orchards.

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Pesticide Transport Models: Comparison and Validation with Soil Column Leaching Experiments

T. Harter[1] **and G. Teutsch**[2]

During the last decade the European Community enforced new drinking water standards allowing a maximum pesticide concentration of 500 ng/l. Local water utilities and environmental and agricultural agencies are challenged to rigidly assess the groundwater contamination potential of pesticides. A number of computer models have been developed for simulating subsurface pesticide transport. They will be an important management tool in coming years. However, not many efforts were directed to validate the usefulness of such models.

Three important management models, the Pesticide Root Zone Model (PRZM) by EPA, the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model by the U.S. Department of Agriculture, and the Leaching Estimation and Chemistry Model (LEACHM) by the University of Cornell were chosen to be validated. The three models use different mathematical concepts to compute one-dimensional flow and transport in a homogeneous, unsaturated soil: 1) GLEAMS uses a 'tipping bucket' technique for both flow and transport computations, 2) PRZM solves the flow problem by a similar 'tipping bucket' approach, but applies a finite difference scheme to solve the advection-dispersion equation, and 3) LEACHM is based on numerical solutions of the Richards equation for unsaturated flow and of the advection-dispersion equation for transport. All three models include a linear adsorption model and first order degradation kinetics. In laboratory experiments, two pesticides, atrazine and terbuthylazine, and a conservative tracer bromide were applied to four different soils packed in stainless steel columns. The unsaturated columns were irrigated daily over a period of three months (pseudo-steady-state). The columns outflow concentrations were recorded to obtain breakthrough-curves (BTC).

The model simulations were based on the results of standard laboratory procedures to analyze the physical and chemical soil/pesticide properties. Model results for total mass transport, BTC arrival time, peak time, and peak concentration differed in general within a factor of two from the measured BTC values of the column experiments. Among the three models, LEACHM and PRZM performed best. Due to the pseudo-steady-state flow conditions, few differences were observed between the results of the two models. However, the computing time of LEACHM was two orders of magnitude beyond that of PRZM. Accuracy of the GLEAMS computations were hampered by strong model dispersion effects that are inherent to the 'tipping bucket' concept.

Calibration of the adsorption coefficient, the degradation constant, and the dispersivity in PRZM and LEACHM lead to reasonable fits of the column BTCs. The calibrated adsorption coefficient varied within a factor of two from those measured in batch-experiments. The calibrated half-life values were up to 50 percent below the laboratory degradation measurements. The calibrated dispersivities varied between 1 and 15 mm and were different for different pesticides. The latter result expresses the insufficiency of the assumptions of linear reversible adsorption and soil homogeneity. Overall, the study results are encouraging and will be important to evaluate further laboratory and field validation studies.

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Validity of Herbicide Prediction Models for Herbicide Movement in the Soil Vadose Zone

D. Penner[2] and R.D. Shaffer[1]

Three computer models were evaluated for prediction of herbicide leaching in soil under Michigan agricultural conditions. The models were 1) the Chemical Movement in Layered Soil (CMLS), 2) the Pesticide Root Zone Model (PRZM), and 3) Groundwater Loading Effects of Agricultural Management Systems (GLEAMS). In studies designed to validate the models, the soybean herbicides metolachlor and alachlor were each applied during preemergence at 2.2 kg/ha. Leaching was monitored at two sites representing two different soil types. Soil samples were analyzed for herbicide residues. Herbicide leaching was monitored over time and soil depth. Comparisons were made among models and between model predictions and observed results. The maximum depth of leaching predicted for each model was PRZM > GLEAMS > CMLS. The leaching depths predicted by the models were not as great as those actually observed in field studies. The maximum depth of detectable metolachlor residues found in June was 61.0 cm at East Lansing and 76.2 cm at Hickory Corners. None of the models successfully predicted such deep leaching depths. Nevertheless, the models were successful in predicting that no detectable herbicide residues would leach below the root zone.

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USDA Forest Service Aerial Spray Dispersion Models AGDISP and FSCBG I: Model Formulation

A.J. Bilanin, M.E. Teske[1],
J.W. Barry[2] and R.B. Ekblad[3]

For the last fifteen years, the USDA Forest Service in cooperation with the U.S. Army, has been pursuing the development of computer models to predict the deposition distribution of aerially released material. As a manager of vast natural resources, the Forest Service recognizes the need for management tools when herbicide and other pesticide applications are necessary. As the need to control the drift of aerially released spray material has increased, so too has the effort to construct computer models to simulate the behavior of the released material.

The two models developed are AGDISP and FSCBG.

AGDISP is a detailed aircraft wake model that solves for the mean position of all material released from the aircraft spray nozzles and the position variance about the mean as a result of turbulent fluctuations. The Lagrangian equation approach tracks the released material through the effects of wing tip vortices, helicopter downwash and forward flight, jet engines and propellers, crosswind, vortex decay, and material evaporation. FSCBG is a Gaussian line-source model that takes the near-wake results of AGDISP and predicts downwind dispersion including the effects of evaporation, meteorology, canopy penetration, and ground and canopy deposition. Both codes operate on personal computers and the Forest Service Data General.

In this paper the idealized flow field models that form the basis for the AGDISP and FSCBG prediction capability will be reviewed. Their model origins, from as far back as 1879, will be discussed. The role that each model plays in the prediction of pesticide applications will be examined. The way in which the two codes complement each other will be emphasized. The approach by the Forest Service in this important area will be summarized: to develop predictive tools that model the fate of aerially released material, to fashion computer codes for these models that run quickly and accurately on personal computers, to provide training on the operation of these codes, and to provide support for the codes to anyone who joins the User Groups formed for the codes.

This historical and background perspective will enable the reader to understand the current modeling efforts undertaken by the Forest Service. Through these models, the USDA Forest Service provides tools that will help ensure safer application of herbicides and other pesticides.

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USDA Forest Service Aerial Spray Dispersion Models AGDISP and FSCBG
II: Model Validation

A.J. Bilanin, M.E. Teske[1],
J.W. Barry[2], and R.B. Ekblad[3]

For the last fifteen years, the USDA Forest Service in cooperation with the U.S. Army has been pursuing the development of computer models to predict the deposition distribution of aerially released material. As a manager of vast natural resources, the Forest Service recognizes the need for management tools when herbicide and other pesticide applications are necessary. As the need to control the drift of aerially released spray material has increased, so too has the effort to construct computer models to simulate the behavior of the released material.

The two models developed are AGDISP and FSCBG.

AGDISP and FSCBG contain simplified models for the complex flow structure behind aircraft (helicopter and fixed wing) and the mechanisms that affect the fate of aerially released material including downwind drift, evaporation, canopy penetration, and ground and canopy deposition. These simple models and the experimental evidence that support them will be reviewed and shown to be faithfully represented within AGDISP and FSCBG. Verification with wind tunnel and laboratory tests will be included. Approximations will be explained, and common sense arguments will be advocated to support assumptions.

Both AGDISP and FSCBG have undergone extensive validation against field test data, including data sets at Dugway Proving Ground (1974), Withlacoochee seed tree orchard (1980), Mission (1987), Heather Douglas fir seed orchard (1989), and an extensive series of tests performed under Program WIND (1985-1986). These 70-plus realizations provide a sizable basis with which to validate both models. Previous validations have been of a qualitative nature. In this paper quantitative validation will be presented using the statistical comparison technique recently developed by Steve Hanna (Sigma Research Corporation). It is anticipated that these comparisons will support the accuracy of the codes to predict ground deposition and drift from aerially released material.

This model comparison perspective will enable the reader to understand the current modeling efforts undertaken by the Forest Service. Through these models the USDA Forest Service provides tools that will help ensure safer application of herbicides and other pesticides.

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Session O -- Nonagriculture Use and Local Management Planning

Moderator: Jay Roberts, Council on the Environment, Richmond

IPM Lawn Care in an Urban/Industrial Complex
P.E. Catron*, NaturaLawn, Inc., Damascus, Maryland

Chlordane Residues in Soil Surrounding Houses in Louisiana
K.S. Delaplane*, Department of Entomology, University of Georgia, Cooperative Extension Service, Athens; J.P. La Fage (Deceased), Department of Entomology, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge

The Olmsted County Comprehensive Water Management Plan: A Strategic Planning Approach
G.C. Isberg*, Metropolitan Waste Control Commission, St. Paul, Minnesota

Comparison of IPM Programs of Three Commercial Landscape Maintenance Companies
E.P. Milhous*, White Oak Pest Management, Inc., Manassas, Virginia

Circle of Change
B.A. Mullarkey*, Wednesday Journal, Inc., Oak Park, Illinois

IPM Lawn Care in an Urban/Industrial Complex

P.E. Catron[1]

In response to continued public awareness on environmental concerns and the excessive use of pesticides by the lawn-care industry, an alternative to the typical chemical lawn-care programs of the 70s and 80s was designed and implemented by NaturaLawn, Inc., in the fall of 1987. The objectives of this alternative program were four fold.

The objectives were to adopt the concept of Integrated Pest Management to a lawn-care situation in such a way that 1) customers could easily and readily understand, 2) technicians would be able to make operational decisions on a day-to-day and lawn-to-lawn basis, 3) the results of the program in terms of lawn quality were either equal to or better than traditional chemical lawn care, and 4) that the economics of the program provided a reasonable return on investment.

In order to fulfill the need for customer acceptance and understanding, a different approach towards marketing and advertising was developed so as to "educate" the customer as opposed to "selling" the customer. This was accomplished in part through the use of a direct mail, four-color piece depicting not the beautiful weed-free green lawn, but rather the lawn(s) that had been environmentally abused by excessive use of pesticides either through improper homeowner applications or professional spray treatments. This pictorial was assisted by an accompanying dialogue which discussed the concept of Integrated Pest Management.

The second objective was met through the implementation of an extensive and continual training program that focused on agronomic factors which gave the technicians a foundation of knowledge with which to make decisions. The decision-making process by technicians about lawns was enhanced by two important factors (1) all vehicles used for lawn treatments carried multiple material choice selections, both biological and synthetic and (2) technicians were financially rewarded for taking the necessary time to review properties so as to assist them in material selection.

The third criteria of better or equal results is to some extent subjective in nature. There are industry ratios of service calls, cancellations, and net growth that can be used for comparative purposes to measure degrees of success or failure. With IPM programs implemented and functioning for a 26-month period, the results showed that there were 76 percent fewer cancellations of lawn-care customers in NaturaLawn's IPM program than industry averages generate. There were also 86 percent less service calls for retreatments for NaturaLawn's IPM programs than for traditional chemical lawn-care industry averages. Net growth achieved in 26 months was comparable to the growth of a chemical company that had been in business a full nine years.

The economics of implementing an IPM lawn-care program is of major concern to most of the industry. While overall costs of materials went down, there were increased costs in the payroll, training, and recruitment areas. The net cost change was negligible, yet a significant increase in profit percentage over industry averages was realized due to a high degree of customer satisfaction that was shown by low cancellations and service calls.

The major results of this 26-month business program included 1) a high degree of customer acceptance, 2) better trained technicians that made more rational pesticide treatment choices, 3) better than industry average in customer satisfaction, and 4) reduced pesticide usage (and cost) and better profit ratios.

Current activities conducted by NaturaLawn, Inc. include additional studies on biological weed-control materials, extended use of certain biological insect controls to ascertain geographical limitations of the organism, and a public relations effort to continue to further educate the general public on the alternative approaches to chemical lawn care utilizing Integrated Pest Management.

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Chlordane Residues In Soil Surrounding Houses in Louisiana

K.S. Delaplane[1] and J.P. La Fage[2]

Chlordane was used widely in the United States as a soil termiticide from the late 1940s until 1988 when its use was banned by the U.S. Environmental Protection Agency. In October 1986, we sampled soil around 30 houses in greater New Orleans, Louisana, and measured within-structure variation in chlordane levels and changes in chlordane levels since the most recent treatment, which ranged from February 1966 to July 1986. Chlordane was present in all samples, and the overall mean (±SEM) was 870.6 ± 96.5 ppm with a range of 0.6 to 14,464.0 ppm. Chlordane residues were unaffected by construction type (crawl space, slab, crawl/slab), depth of soil sampling (0-5 cm or 6-10 cm), or number of years post-treatment (0.25 years to 20 years). However, there was considerable variation of chlordane residues within individual structures. Within-house variation was highest in slab structures and lowest in crawl space structures; crawl/slab structures were intermediate and did not differ from other types. Apparently, technicians using chlordane, and probably any soil termiticide, treat crawl space structures more uniformly than they treat slabs. This extreme variation may allow "weak points" in a soil termiticide barrier where termites can breach the barrier and attack the structure. Indeed, 14.2% of our sample sites had residues below the minimum requirement (Louisiana Department of Agriculture) of 100 ppm and were vulnerable to attack by *Coptotermes formosanus* Shiraki, an aggressive, exotic termite common in New Orleans. Research is needed to improve uniformity of soil termiticide application.

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The Olmsted County Comprehensive Water Management Plan: A Strategic Planning Approach

G.C. Isberg[1]

Olmsted County, with a land area of 656 square miles, is located in the southeastern part of Minnesota. The geology of the area is known as karst, which is characterized by limestone and dolomite bedrock with fissures and cracks as well as a number of sinkholes, making the groundwater particularly susceptible to pollution from a variety of urban and rural sources.

In the early part of 1987, Olmsted County placed groundwater protection as a high priority among many competing programs and started a 2-year comprehensive water management plan which was adopted in December, 1989. The plan and the process used to develop the plan is unique in several respects. For one, it uses a strategic planning approach by analyzing the existing background data: developing a mission statement and goals and policies, developing a valid system of priorities among many competing programs, focusing the efforts on the most critical issues, and placing a major emphasis on implementation strategies matched with available resources. Second, the process involves a truly intergovernmental and interdisciplinary approach in the development of the plan. Approximately 45 professionals from 15 federal, state, and local agencies provided the technical information related to water resources through a series of task forces. Third, the plan was developed by an "in-house" staff and policy committee made up of local officials, thus creating local ownership over the plan giving it reasonable assurance that the plan will be implemented even in the face of opposition by different interest groups. Fourth, the planning process used specific and identifiable standards and criteria in establishing the system of priorities among the competing programs, thus increasing the probabilities that the plan and implementation programs and strategies will withstand future legal challenges. Fifth, the process encourages public input through various public information meetings, surveys, newspaper publicities, and public hearings.

The following are the major lessons learned from the county planning process:

- Lack of Relevant, Specific, and Systematic Background Data - much background data related to groundwater pollution needs to be developed on a systematic basis;
- Contradictory Interpretations of Background Data - major disagreements between scientists on interpretations of data became evident or what some have called the "dueling scientists";
- Lack of Credibility of Public and Private Institutions - the public is confused and disillusioned over contradictory data and policies as well as statements by decisions-makers;
- Need for Intergovernmental Coordination - inter- and intra-coordination and holistic approaches are essential;
- Water Management Issues and Land Use Control Boundaries Do Not Correspond - this is a major paradox that needs to be dealt with for efficient implementation programs;
- Water Management Issues Do Not Correspond To Existing Departmental Organizations of Governmental Units - need to change the existing organization to better fit water management problems, i.e. the team approach.

Some of the major benefits of the planning program and processes:

- Heightened public awareness of the complexity of water management issues,
- Indicated strong public support for proposed water management programs,
- Brought about closer working relationships between various public and private sector agencies,
- Created "Ownership" of the plan among participating public and private agencies,
- Resulted in the start of a two-year systematic groundwater monitoring program for Rochester and six surrounding townships, and
- Resulted in the start of five-year Minnesota Extension/S.C.S. cooperative study of rural land use practices in six township areas.

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Comparison of IPM Programs of Three Commercial Landscape Maintenance Companies

E.P. Milhous[1]

It has been reported that Americans annually spend more money nationwide on lawn and landscape care than on the major grain crop corn. Fertilizers and pesticides are applied on suburban residential properties at rates that exceed application rates on many agronomic and horticultural crops. It is yet to be determined how much of these pesticides and nutrients find their way into our water systems, but as the "greens" industry continues to grow, the total amount used will increase. Another environmental problem created by the industry, and homeowners who imitate it, is the tremendous waste problem: grass clippings and pruning debris fill 25 to 30 percent of landfill space used from March through October. An industry that most get involved with because of their love of nature and the outdoors, needs to do something about these two environmental problems, and it's beginning to do so. A few commercial landscape-maintenance companies in North Virginia/suburban Maryland are offering Integrated Pest Management programs to their customers. This paper will describe three such companies' methods and results and compare them to another company's traditional cover-spray program.

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Circle of Change

B.A. Mullarkey[1]

Circle of Change describes a 2-year individual involvement to change the pesticide policy of Oak Park, Illinois. It begins with the paralysis and death of BeeLee, my 12-year-old daughter's kitten. This incident and one involving the deaths of five dogs of mixed breeds and ages on one village block prompted my interest in a pesticide link. Two letters to the editor of our local paper from a resident about the hazards of pesticides on pets and humans spurred more questions. Another woman linked the death of her dog to pesticides in our parks.

On May 23, 1988, Oak Park's Environmental & Energy Advisory Commission met to discuss pesticides. Our health director released a two-month study of pesticide literature. Two women initiated a petition drive and gave our village officials 1,400 signatures of people who objected to officials' use of pesticides. In less than a year, our small nucleus of women attended more than 35 meetings on pesticides. In the process we educated ourselves, our village, and other communities about pesticides and safe alternatives through local and Chicago newspapers and cable and network TV.

In January, 1989, our grammar school District 97 board members voted 7-0 for a landscape contract "provided no pesticides will be used without prior consent of the school board." In February, 1989, people on both sides of the pesticide issue spoke at a public hearing. On April 3, 1990 Oak Park village trustees, by a 7-0 vote, passed a pesticide license and notification ordinance for outdoor and indoor application.

The International City Management Association included Oak Park's ordinance in its Management Information Service (MIS) report *Pesticide Management for Local Governments* (Vol. 2, no. 8, August, 1989), which goes to 1,400 U.S. towns. In June, 1990, Aurora, Illinois, passed an ordinance based on that of Oak Park.

District 200 and the Oak Park and River Forest High School board administratively decided in May 1989 to suspend the use of outdoor pesticides for one year. An excerpt from the minutes of a September 1989 village board meeting states: "The consensus of the Board was that its basic responsibility was the protection of the health and welfare of Oak Park citizens; therefore the use of any chemical or toxic substances not proven safe through expert advice and/or public hearing should be disallowed on any village owned properties." The board members commissioned health department officials to study and report on Integrated Pest Management (IPM). A previous village board in 1983 banned malathion fogging for mosquitoes.

District 97 extended its pesticide moratorium for another year. The village board, District 200, and the park district board voted to implement IPM.

Information continues to pass through concerned citizens' hands to village officials on the available safe alternatives to pesticides. Personal and professional pesticide education and awareness is a continuous process.

In April 1990, Illinois environmentalists formed Mother Earth Network (MEN) to share knowledge and insist MEN act for safe air, water, food, light, energy, and products. More than 30 communities have ties to MEN, and other states' nature-conscious groups have expressed interest in joining MEN.

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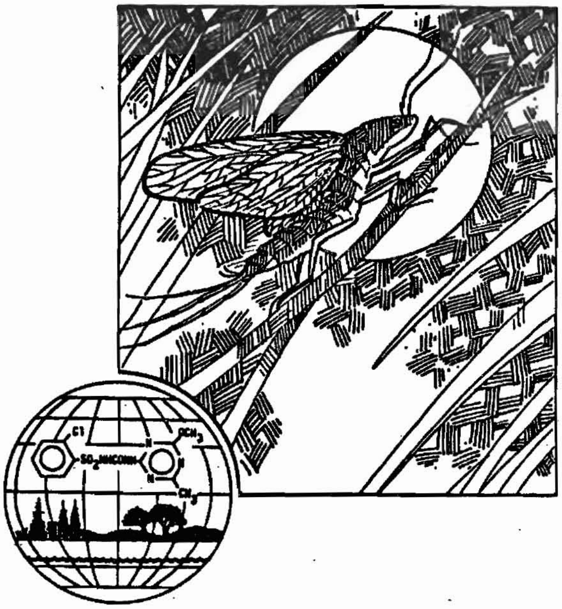
Index of Presenters

Proceedings of Second National Pesticide Conference



Proceedings of the Virginia Water Resources Research Center's 1989 national pesticide research conference are available for $25. The proceedings of ***Pesticides in Terrestrial and Aquatic Environments*** edited by Dr. Diana L. Weigmann are more than 500 pages long and include 50 research papers on risk assessment, monitoring, toxicity, waste disposal, environmental regulations, effects of pesticides on nontarget species, and pesticide contamination of drinking water supplies, wastewater sludge, groundwater, and surface water.

To request copies of the conference proceedings, return the form below to Publications Services, Virginia Water Resources Research Center, 617 N. Main St., Blacksburg, VA 24060-3397. For further information, call (703)231-8036.

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