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USA–USSR SYMPOSIUM ON ENVIRONMENTAL TRANSPORT AND TRANSFORMATION OF PESTICIDES

Under the 1972 USA–USSR Agreement on Cooperation in the Field of Environmental Protection, a joint project committee on environmental transport of agricultural chemicals (pesticides and fertilizers) began a cooperative program of information exchange in December 1974. Scientists of both countries visited major research centers for familiarization with agricultural use of pesticides and nutrients and with current concepts and research on environmental effects of these chemicals.

To focus on a scientific question of particular mutual concern, the joint project committee sponsored a 7-day symposium on the Environmental Transport and Transformation of Pesticides, which was hosted by the Soviet side at Tbilisi, Oct 20–27, 1976. The Symposium was held in conjunction with the fourth meeting of the USA–USSR Joint Project Committee for Project 02.03-31, "Forms and Mechanisms by Which Pesticides and Chemicals Are Transported". Eleven U.S. delegates met with 26 Soviet scientists to discuss six main topics. Opening remarks by G. G. Svanidze (USSR), D. W. Duttweiler (USA), and S. G. Malakhov (USSR) emphasized mutual interest in the subject, the importance of pesticides to agricultural productivity, and the value of scientific understanding of the environmental entry, transport, transformation, ecological effects, and ultimate residual distribution of pesticides.

Pesticide Movement and Transformations in the Atmosphere

(Co-Chairmen: D. G. Crosby (USA) and S. G. Malakhov (USSR))

Papers were presented by D. G. Crosby (USA); V. A. Borzilov, V. M. Koropalov, S. G. Malakhov, I. M. Nazarov, A. I. Osadtchy (USSR); and F. P. Vaintraub, G. F. Vylegzhanina, L. L. Chernichuk, I. A. Konjukhova (USSR).

Pesticides have been detected in the atmosphere at many locations in the world, sometimes at distances remote from pesticide use. The escape of these chemicals into the atmosphere represents an economic loss to the user, inefficient control of pests, and introduction of possible environmental contamination. Work on this subject is at an early stage.

Several factors contribute to the observed atmospheric residues. As demonstrated with Disparlure, pesticides can volatilize from plant and soil surfaces, the process being strongly influenced by air movement and temperature. Volatilization also can occur readily from the surface of water, the rate depending on mass-transfer coefficients in water and air. Wind erosion carries pesticides on dust into the atmosphere and distributes them over great distances, and direct introduction of pesticide formulations at the time of application also makes a small contribution.

However, pesticides probably do not remain in the atmosphere. The rate at which they return to earth depends upon their concentration, the deposition rate of aerosol particles, and the turbulent exchange coefficient, as seen from the comparison of DDT in the Fergana Valley and in the Khoresm Oasis. The particles and probably part of the pesticide vapor also can be precipitated in rain, and vapor may diffuse slowly into the stratosphere. Present evidence indicates that pesticides as vapor and on solid surfaces decompose by the action of sunlight. Decomposition can be surprisingly rapid, as demonstrated with the herbicide trifluralin and several juvenile hormone analogues; oxidation reactions predominate.

The atmospheric movement and transformation of pesticides represent a major part of the environmental disposition of pesticides and are of great importance in safer and more efficient pesticide use. Immediate research needs include a catalog of vapor pressure data, more efficient air sampling methods, laboratory and field estimates of the vapor-adsorption equilibria on airborne particles, and knowledge of the factors affecting pesticide photodecomposition in vapor and on surfaces.

Pesticide Transport and Transformation in Soils (Co-Chairmen: D. D. Kaufman (USA) and M. S. Sokolov (USSR))

Six papers were devoted to the problem of pesticide migration, to biotic and abiotic transformation of xenobiotics in natural and model ecosystem environments, and to the physical and mathematical modeling of these processes. Considerable attention was given to the problems of methodology and techniques. The possibility of using the data obtained for forecasting and for controlling the behavior of xenobiotics under natural conditions was discussed.

G. W. Bailey (USA) described a model that interpreted and simulated the principal processes of xenobiotic transport, behavior, and transformation in and from the soil. A concern was expressed that full-scale models be completely representative. The importance of an interdisciplinary approach to finalizing a definitive model and generating a data base to validate the model was also emphasized.

M. S. Sokolov (USSR) described intrasoil transport of residues of xenobiotics used in rice irrigation systems. The importance of full-scale experiments for clarifying the factors that account for the dissipation of xenobiotics from the environment was emphasized. The expediency of model ecosystems for obtaining data necessary for predicting xenobiotic behavior under actual environmental conditions was also discussed.

G. G. Zhdamirov (USSR) presented an equation which describes the dependence of co-evaporation on the xenobiotic concentration in water, vapor pressure, and temperature. From the results of model experiments, it was recommended that partitioning or accumulation coefficients would be useful in understanding xenobiotic behavior in soil–plant systems.

D. D. Kaufman (USA) described and compared several systems, including soil perfusion columns, biometers, and an agroecosystem used for examining xenobiotic behavior in soil, water, and biota. The agroecosystem permits the combined study of xenobiotic transformation and transport in the soil–plant–air–water–biota system for a prolonged period of time during growth of the crop.

L. A. Golovleva (USSR) presented data on the possible use of cometabolism as a mechanism for transformation and degradation of xenobiotics. The cometabolism phenomenon was discussed in connection with structurally related and natural carbon sources as inducers for activating xenobiotic degrading microorganisms. Application of this phenomenon to xenobiotic residue problems deserves further investigation.

Data presented by E. I. Gaponyuk (USSR) suggest the possible use of soil dehydrogenase activity as a criterion for determining the effect of xenobiotics on soil biological activity. Practical application of this technology was discussed in some detail.

Discussions concluded that computer techniques should be considered for solving problems related to the multifactor processes involved with environmental fate and behavior of xenobiotics; additional information is needed regarding movement and transport of pesticides in ground and artesian water in areas of intensive xenobiotic application; and the use of cometabolic processes for elimination of xenobiotic residues from the environment, and selection of indicator criteria, e.g., soil dehydrogenase activity, for assessing xenobiotic effects on soil biota deserve further investigation.

Transport and Transformation of Pesticides in Water (Co-Chairmen: G. L. Baughman (USA) and M. N. Tarasov (USSR))

Water pollution may be one of the most serious aftereffects of pesticide application. The health of man as well as the quality of environmental media (soil, water, air, biota) depend directly on the quality of water. Current research efforts have focused on three main areas: determination of pesticide persistence in water, study of transformation products, and delineation of the processes of pesticide transport in water.

G. L. Baughman (USA) reviewed the influence of biotic and abiotic factors on the kinetics of pesticide degradation processes, the kinetics of sorption by microorganisms and sediments, and the kinetics of pesticide volatilization. Attention was focused on progress in determining mechanisms and developing equations describing pesticide dynamics.

C. I. Bobovnikova, E. P. Virchenko, G. K. Morosova, Z. L. Sinitzina, and Y. P. Cherkhanova (USSR) reported on experiments concerning loss of some pesticides in surface runoff from agricultural lands. A similar problem was examined by L. G. Korotova and A. S. Demchenko (USSR), who also touched upon the processes of pesticide degradation in soil.

E. E. Kenaga (USA) examined water as a medium for transport and redistribution of pesticides. Data were presented on the distribution coefficients for pesticides in various components of aquatic ecosystems. The distribution coefficient for the binary 1-octanol/water was suggested for estimation of possible pesticide accumulation in aquatic biota. Subsequent discussion concluded that more laboratory studies are needed for understanding the environmental processes that control the rates of pesticide transformation and transport, further work is needed in predicting pesticide transport from agricultural land to aquatic systems, and use of distribution coefficients for predicting potential bioaccumulation should be further studied.

Pesticide Transport and Transformation in Plants (Co-Chairmen: J. J. Menn (USA) and F. P. Vaintraub (USSR))

The four papers presented in this session dealt with the fate of pesticides in plants, their uptake from soils or arboreal portions of plants, movement in plants, biological and nonbiological degradation, and determination of metabolic pathways for pesticides.

Plants serve as a major reservoir of pesticides due to plant protection practices; their ability to detoxify xenobiotics is of key importance in ameliorating possible environmental and health effects of pesticides.

D. S. Frear and J. J. Menn (USA) discussed the metabolic fate of model herbicides and insecticides, respectively. Little information is currently available on the microsomal enzymes in plants responsible for many important biotransformation reactions of xenobiotics. The fate of conjugated and bound metabolites was also examined with reference to their significance as terminal metabolites (residues) in plants. Metabolic pathways of xenobiotics were compared in plants and animals. In most instances, these pathways involve similar detoxification processes.

F. P. Vaintraub (USSR) discussed the effects of sunlight, temperature, moisture, wind and formulation on the persistence and transformation of pesticides on plant surfaces. Several model pesticides were investigated. It was shown that photolysis and volatilization are important in degradation and intramolecular rearrangements. However, it was pointed out that great care should be exercised in interpreting data obtained under artificial conditions as they may not always relate to actual field conditions. For example, phthalophos photolyzes rapidly under laboratory conditions to phthalimide, a product that disappears very rapidly under field conditions.

T. M. Petrova (USSR) discussed the behavior and persistence of organic phosphorus insecticides in plant/soil systems under controlled and field conditions. Absorption and metabolism of foliar applied insecticides was controlled by cuticular wax deposition, and by action of plant enzymes such as peroxidase and esterases.

Future research needs include development of improved analytical methods, studies on pesticide interactions, determination of environmental and genetic effects on pesticide behavior, and expanded studies with in vitro systems.

Pesticide Transport and Transformation in Animals
(Co-Chairmen: J. E. Casida (USA) and Y. S. Kagan (USSR))

Pesticides are potentially hazardous for human health since they are selected for high biological activity in pest organisms and some of them are persistent in the environment, are concentrated in food chains, and are consumed as dietary contaminants. This risk is minimized with adequate understanding of pesticide metabolism in higher animals.

J. E. Casida (USA) discussed progress in developing synthetic pyrethroids which combine high insecticidal potency, low mammalian toxicity, rapid biodegradability, and sufficient stability on crops to serve as possible replacements for chlorinated hydrocarbon insecticides. He also considered the metabolism of thiocarbamate herbicides, information useful in defining conditions for their safe and effective use and in finding new herbicidal analogues.

Y. S. Kagan (USSR) reviewed the major results and trends of pesticide toxicological research in the USSR, with emphasis on the criteria and procedures for evaluating new compounds prior to their use in agriculture. His toxicological studies with mammals confirm the harmful effects of small quantities of DDT. His findings on metabolism of organophosphorus pesticides lay the foundation for developing new compounds with reduced hazard for mammals.

J. J. Lech (USA) discussed the persistence and metabolism of phenolic pesticides and polychlorobiphenyls (PCBs) in fish. Residues of PCBs in fish are a serious problem in the USA, and elsewhere. He showed data demonstrating that analysis of pesticide content in fish fat and bile are useful in environmental monitoring for pollution of aquatic systems.

G. A. Talanov (USSR) indicated the routes by which farm animals are exposed to a variety of pesticides and the significance of residues derived from these compounds in meat, milk, and eggs. Residue problems created by the chlorinated hydrocarbons are largely avoided by shifting to organophosphorus insecticides.

The main goals for future research on pesticide metabolism in animals should be development of analytical methods with increased sensitivity and specificity; definition of pesticide mode of action at the physiological and biochemical levels; use of this knowledge to discover new, selective compounds with minimal effect on higher animals; and investigations of allergic, teratogenic, mutagenic, and carcinogenic effects to lay a data base for predicting long-term consequences of pesticide exposure on humans and animals.

Mathematical Modeling
(Co-Chairmen: D. W. Duttweiler (USA) and V. M. Voloshchuk (USSR))

Mathematical modeling of pesticide migration and transformations in the environment, using the present state-of-the-art in mathematics and highly developed computational techniques, is one of the most efficient methods for investigating this problem. The papers presented at the session were devoted to the review of the present state of this problem, analysis of the results obtained, and determination of key topics for future research.

J. Hill (USA) described a basis for developing a general ecosystem model for mathematical modeling of pesticide behavior in the environment. Such a model can be developed using the theory of hierarchical models. In this case the processes in the whole ecosystem can be considered quasilinear in the first approximation; the theory of influences can be used to determine the structure of the system and reduce it to a combination of simple submodels and interactions between them.

V. M. Voloshchuk (USSR) advocated qualitative mathematical analysis for studying the effect of anthropogenic contamination on the dynamics of populations using ordinary differential equations. As an example, he demonstrated the analysis of possible responses of soil or water microflora to the short-time perturbation resulting from application of agricultural toxicants or mobilization of their action.

V. V. Rachinskii (USSR) described an analysis of vertical pesticide migration in the upper soil layer having a constant coefficient of vertical diffusion, constant vertical velocity of filtration of the solution, and various model representations of sorption isotherms.

E. I. Spynu and L. N. Ivanova (USSR) described a multiple regression technique and its application for investigating the problem of pesticide migration in the system "soil–plant roots–stem." They obtained predictive relationships that facilitate predictions of residues and half-lives of pesticides in different crops under different conditions.

V. M. Koropalov and I. M. Nazarov (USSR) suggested a model of pesticide circulation in the biocenosis using the Fergana Valley as an example.

Discussion concluded that future research should emphasize the use of evaluative models to plan and carry out field experiments, and the development of predictive mathematical models for whole ecosystems on the basis of the information obtained a priori and in laboratory and field experiments.

CONCLUSION

In addition to the formal presentation and discussion of papers, ample opportunity was afforded for discussion of specific scientific problems of mutual interest. American and Soviet participants were well satisfied with the exchange of information that took place at the symposium and agreed that it will promote the development of scientific research in the United States and the Soviet Union. The establishment of cordial relations between leading scientists in the two countries concerned with environmental effects of agricultural pesticides and the stimulation of normal scientist-to-scientist communication were recognized as welcome accomplishments of the symposium.

The extended abstracts of the papers presented at the symposium will be published in both languages, the English version in the USA and the Russian version in the USSR. The English version is scheduled to be published as a U.S. Environmental Protection Agency Report from the Athens Environmental Research Laboratory in July 1977.

D. W. Duttweiler
S. G. Malakhov

U.S. Environmental Protection Agency
Environmental Research Laboratory
Athens, Georgia 30601
and Institute of Experimental Meteorology
Obninsk, USSR

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Appendix I: List of the Soviet Participants at the Soviet-American Symposium in Tbilisi (Oct 20–27, 1976)

Malakhov, S. G., Chief of Department, Institute of Experimental Meteorology, Kaluzhskaya Oblast, Obninsk, 249020.
Svanidze, G. G., Director of the Transcaucasian Hydrometeorological Research Institute, Tbilisi, 380012.
Chantladze, Z. I., Chief of Department, Transcaucasian Hydrometeorological Research Institute, Tbilisi, 380012.
Voloschuk, V. M., Deputy Director, Institute of Experimental Meteorology, Kaluzhskaya Oblast, Obninsk, 249020.
Borzilov, V. A., Chief of Laboratory, Institute of Experimental Meteorology, Kaluzhskaya Oblast, Obninsk, 249020.
Starikov, Vu. A., Hydrometeorological Service of the USSR, Moscow, D-376.
Bobovnikova, Ts. I., Chief of Laboratory, Institute of Experimental Meteorology, Kaluzhskaya Oblast, Obninsk, 249020.
Zhdamirov, G. G., Institute of Experimental Meteorology, Kaluzhskaya Oblast, Obninsk, 249020.
Gapanjuk, E. I., Institute of Experimental Meteorology, Kaluzhskaya Oblast, Obninsk, 249020.
Osadchy, A. I., Institute of Experimental Meterology, Kaluzhskaya Oblast, Obninsk, 249020.
Sokolov, M. S., Chief of Laboratory, Institute of Agrochemistry and Soil Science, Moscow Region, 142292.
Kudeyarov, V. N., Head, Laboratory of Nutrients Balance, Institute of Agrochemistry and Soil Science, Moscow Region, 142292.
Talanov, G. A., Deputy Director, Institute of Veterinary Sanitation, Moscow D-22.
Rachinsky, V. V., Head of the Chair, Timiryazev Agricultural Academy, Moscow A-8.
Kaplin, V. T., Chief of Department, Hydrochemical Institute, Novocherkassk, Rostov Region.
Galitsky, K., Institute of Agrochemistry and Soil Science, Moscow Region, 142292.
Sinitsina, Z. L., Institute of Applied Geophysics, Moscow 123810.
Golovleva, L. A., Chief of Laboratory, Institute of Biochemistry of Microorganisms, Moscow Region, 142292.
Vaintraub, F. P., Chief of Department, Institute of Biological Methods of Plant Protection, Kishinev.
Koropalov, V. M., Institute of Applied Geophysics, Moscow 123810.
Spynu, E. I., Chief of Department, Institute of Hygiene and Pesticide Toxicology, Kiev 127.
Kagan, Yu. S., Chief of Department, Institute of Hygiene and Pesticide Toxicology, Kiev 127.
Ivanova, L. N., Institute of Hygiene and Pesticide Toxicology, Kiev 127.
Tarasov, M. N., Chief of Laboratory, Hydrochemical Institute, Novocherkassk, Rostov Region.
Demchenko, A. S., Hydrochemical Institute, Novocherkassk, Rostov Region.
Vernichenko, A. A., Institute of Water Protection, Kharkov, 59.

Appendix II: List of U.S. Participants at the Soviet-American Symposium in Tbilisi (Oct 20–27, 1976)

Bailey, G. W., Acting Associate Director for Rural Lands Research, U.S. EPA Environmental Research Laboratory, Athens, Georgia 30601.
Baughman, G. L., Chief, Environmental Processes Branch, U.S. EPA Environmental Research Laboratory, Athens, Georgia 30601.
Casida, J. E., Department of Entomology, University of California, Berkeley, California 94720.
Crosby, D. G., Department of Environmental Toxicology, University of California, Davis, California 95616.
Duttweiler, D. W., Director, U.S. EPA Environmental Research Laboratory, Athens, Georgia 30601.
Frear, D. S., Research Leader, USDA Metabolism and Radiation Research Laboratory, State University Station, Fargo, North Dakota 58102.
Hill, J., IV, Research Environmental Engineer, Technology Development and Applications Branch, U.S. EPA Environmental Research Laboratory, Athens, Georgia 30601.
Kaufman, D. D., Research Microbiologist, Pesticide Degradation Laboratory, USDA Beltsville Agricultural Research Center–West, Beltsville, Maryland 20705.
Kenaga, E. E., Associate Scientist, Dow Chemical USA, Midland, Michigan 48640.
Lech, J. J., Department of Pharmacology, Medical College of Wisconsin, Milwaukee, Wisconsin 53233.
Menn, J. J., Manager, Biochemistry Department, Mountain View Research Center, Stauffer Chemical Company, Mountain View, California 94042.

Appendix III: List of the Interpreters at the Soviet-American Symposium in Tbilisi (Oct 20–27, 1976)

Naumova, N. N., Institute of Agrochemistry and Soil Science, Moscow Region, 142292.
Koretskaya, T. V., Institute of Experimental Meterorology, Kaluzhskaya Oblast, Obninsk, 249020.
Zayavlina, A. P., Institute of Applied Geophysics, Moscow 123810.
Fligelman, U. V., Hydrochemical Institute, Novocherkassk, Rostov Region.

End of Symposium