Sediment Toxicity and Fate of Synthetic Pyrethroids

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REVIEW OF STUDIES ON PARTITIONING, TOXICITY, AND BIOAVAILABILITY OF SYNTHETIC PYRETHROIDS IN SEDIMENTS

INTRODUCTION

Synthetic pyrethroids are a class of chemicals that have been introduced over the past two decades for a variety of insecticidal uses including both agricultural and domestic applications. The synthetic pyrethroids were conditionally registered beginning in 1984 for use on cotton and later for use on other major crops including corn, soybeans, and sugarcane. Currently, EPA is assessing risks to non-target organisms for ten synthetic pyrethroids: bifenthrin, cyfluthrin, cypermethrin, deltamethrin, fenpropathrin, fenvalerate, cyhalothrin, tefluthrin, tralomethrin, and permethrin. Each of these synthetic pyrethroids are conditionally registered for use on cotton, with the exception of tefluthrin, which is conditionally registered for use on corn. Each of these chemicals is highly lipophilic and in aquatic environments tend to strongly adsorb to sediments. OPP's traditional methods for evaluating pesticide risks to aquatic species focus on ecological effects from exposure to chemicals in the water column compartment of the aquatic environment and do not consider exposure of aquatic organisms to benthic sediments. Based on the affinity for synthetic pyrethroids to partition to sediments, EPA identified the need to evaluate the environmental fate and potential toxicity of synthetic pyrethroids in aquatic sediments. To address this need, the Pyrethroid Working Group (PWG), comprised of the major manufacturers of synthetic pyrethroids registered for cotton in the United States, in conjunction with the National Cotton Council, developed a program of studies to evaluate the partitioning, bioavailability, and toxicity of the cotton synthetic pyrethroids in sediment. Scientists from EPA and PWG worked together to define the scope of these studies, based on the most current knowledge and methods available for assessing sediment toxicity. In particular, these studies were intended to investigate the following:

- Rapidity and extent of adsorption of synthetic pyrethroids to sediments, and desorption from sediments;

- Bioavailability of synthetic pyrethroids in sediment to aquatic organisms (water column and benthic) and time to equilibrium of concentrations in sediment, water, and organism phases; and

- Toxicity of synthetic pyrethroids in aquatic sediments to benthic organisms.

Of the nine synthetic pyrethroids that are conditionally registered for use on cotton, cypermethrin was selected as the chemical to be used in these studies because it is one of the most studied synthetic pyrethroids in the laboratory and the field with regard to ecological effects and environmental fate data. In addition, it was determined that there is a greater correlation between field and laboratory data for cypermethrin than for the other synthetic pyrethroids. EPA intended that the results of these studies would serve as the foundation of an assessment of risks to non-target aquatic organisms from use of synthetic pyrethroids on cotton. Subsequently, OPP determined the need to also address the non-target organism impacts from the use of tefluthrin on

corn. Consequently, tefluthrin is being included in OPP's aquatic risk assessment for synthetic pyrethroids. OPP expects to present the methodology and results of this risk assessment at the May 1999 meeting of the FIFRA SAP. The studies performed by the PWG include the following:

PWG #1: Gentle, W., Goggin, U., Rapley, J.H., Farrelly, E., and Hamer, M.J. 1996. Cypermethrin: oxicity to *Chironomus tentans* in Sediment-water Systems. Zeneca Agrochemicals Report No. RC0001. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-02.

WG #2: Farrelly, E., Gentle, W., Goggin, U., Rapley, J.H., and Hamer, M.J. 1996. Cypermethrin: Toxicity to *Hyalella azteca* in Sediment-water Systems. Zeneca Agrochemicals Report No. RC0006. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-06.

PWG #3: Rapley, J.H., Hamer, M.J., and Goggin, U. 1996. Cypermethrin: Bioavailability to *Daphnia magna* in Sediment-water Systems. Zeneca Agrochemicals Report No. RC0003. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-03.

PWG #4: Gentle, W.E., Goggin, U., Rapley, J.H., and Hamer, M.J. 1996. Cypermethrin: Bioavailability to *Chironomus tentans* in Sediment-water Systems. Zeneca Agrochemicals Report No. RC0005. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-05.

PWG #5: Goggin, U., Gentle, W., Hamer, M.J., and Lane, M.C.G. 1996. Cypermethrin: Adsorption and Desorption Properties in Sediment. Zeneca Agrochemicals Report No. RC0004. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-04.

PWG #6: Maund, S.J., Hamer, M.J., and Kedwards, T.J. 1996. Partitioning, Bioavailability, and Toxicity of Cypermethrin in Aquatic Sediments: Overview of a Work Program of the Pyrethroid Working Group. Zeneca Agrochemicals Report No. RC0007. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-07.

PWG #7: Rapley, J.H., Hamer, M.J. 1996. Toxicity to *Chironomus riparius* and *Hyalella azteca*. Zeneca Agrochemicals Report No. RC0002. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440774-01.

A copy of PWG #6 is provided as a support document.

In February 1999, The Office of Pesticide Programs (OPP) will present to the FIFRA Scientific Advisory Panel (SAP) results from sediment toxicity, bioavailability, and adsorption/desorption studies performed by the Pyrethroid Working Group. OPP is seeking the SAP's advice concerning the adequacy of these studies to characterize partitioning, bioavailability, and toxicity of synthetic pyrethroids in sediments. In February, OPP will present their evaluation

of the studies performed by the PWG, OPP's assessment of the physical-chemical properties and environmental fate characteristics of synthetic pyrethroids, and its assessment of sediment toxicity and bioavailability of synthetic pyrethroids. OPP would like SAP's response to the questions that follow:

(1) Are the physical-chemical properties, environmental fate characteristics, and water column toxicity of synthetic pyrethroids similar enough that one chemical, cypermethrin, can be used to represent sediment toxicity of synthetic pyrethroids as a class? If not, could any single one of the other synthetic pyrethroids examined be used to represent sediment toxicity of synthetic pyrethroids as a class? If none of these chemicals individually can be used to represent synthetic pyrethroids as a class, which and how many of these chemicals can be used to represent sediment toxicity of synthetic pyrethroids as a class? Please provide the basis for your conclusions.

(2) Based on our interpretation of PWG data as well as data submitted to the Agency for individual synthetic pyrethroids, we have determined that the correlation between sediment partition coefficient (K_d) and organic carbon content of sediments is weak. Therefore, OPP thinks the concept of K_{oc} is of little value in explaining the binding behavior of synthetic pyrethroids to sediment. On the other hand, available data indicate that there is a strong correlation between benthic organism body burden per dose and K_d. Given these findings, OPP plans to use K_d rather than K_{oc} to estimate concentrations of synthetic pyrethroids in aquatic sediments. Does the panel agree or disagree with this interpretation? What is the basis for your conclusion?

(3) ASTM guidelines suggest testing sediment toxicity using a sediment to water volume ratio of 1 to 1. These guidelines were not finalized at the time the PWG initiated its sediment toxicity testing for cypermethrin. Sediment toxicity tests conducted by the PWG were performed with a sediment to water ratio of 1 to 25. Amphipods such as Hyalella can, however, avoid toxicity originating from synthetic pyrethroids in aquatic sediments by swimming away from the sediments toward the overlying water column. Can the panel help OPP to weigh the importance of this deviation from the current ASTM guidelines for sediment to water ratio? Would its effect on acute sediment toxicity be expected to significantly affect the overall risk assessment? What is the basis for your conclusion?

(4) The authors of the PWG study to evaluate bioavailability of cypermethrin to Daphnia magna in sediment-water systems suggest that the concentration of cypermethrin in sediment is a better predictor of concentration of cypermethrin in the organism than is the concentration of cypermethrin in the water column. As a result, these authors propose using a sediment bioconcentration factor (BCF_s), calculated as the concentration in the organism divided by the concentration in the sediment, as an indicator of bioavailability to sediment-dwelling organisms. Is a sediment bioconcentration factor (BCF_s) a useful concept in conducting sediment risk assessments? If so, how should BCF_s be applied in assessing exposure and risk to sediment-dwelling organisms?

To assist the panel in responding to these questions, the following documents are provided:

EPA #1: Data Evaluation Record, 70-1, Special Test: Acute Sediment Toxicity Test with a

Freshwater Invertebrate. Reviewed by Miachel Rexrode. (Provides a review of Gentle et al., PWG #1.);

EPA #2: Data Evaluation Record, 70-1, Acute Sediment Toxicity Test with a Freshwater Invertebrate. Reviewed by Miachel Rexrode. (Provides a review of Farrelly et al., PWG #2.);

EPA #3: Memorandum from Ron Parker, Environmental Fate and Ground Water Branch to George Larocca, Registration Division. Subject: Review of sediment toxicity data and draft risk assessment. (Provides a review of studies numbered PWG #3 - 6.);

EPA #4: Peer Review Comments on Toxicity, Bioavailability, and Adsorption/Desorption of Cypermethrin in Sediment-Water Systems. From James Lazorchak, National Exposure Research Laboratory to Vivan Turner, Office of Science Policy. (Provides peer review by the Office of Research and Development of the PWG studies and OPP's reviews of these studies.);

EPA #5: Comparative Environmental Fate Assessment for the Synthetic Pyrethroids prepared by Jose Melendez, dated January 14, 1999; and

EPA #6: Synthetic Pyrethroid Summary of Aquatic Toxicity Data prepared by Miachel Rexrode, dated January 11, 1999.

EPA #7: Data Evaluation Record, 70-1 - Special Test: Acute Toxicity Test with Freshwater Invertebrates. Reviewed by Michael Rexrode. (Provides a review of Rapley and Hamer, PWG #7).