



Pyrethroid Insecticides in Nursery Runoff: Transport and Impact on Aquatic Invertebrates

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Synthetic pyrethroids, used by agriculture as insecticides, are toxic to aquatic organisms, especially invertebrates. We have found that the actual toxicity of pyrethroids within irrigation run-off is reduced in the presence of suspended solids and dissolved organic matter (DOC). This inhibition of pyrethroid toxicity results from its ready absorption onto suspended solids and DOC. This suggests that any water quality criteria developed to delimit the amount of pyrethroids acceptable within freshwater systems should be based on monitoring its concentration dissolved in the liquid phase, since the bioavailability of pyrethroids absorbed on solids and DOC is greatly reduced.

The research focus of this project is to evaluate the behavior and ecotoxicological effects of synthetic pyrethroids in runoff on aquatic organisms. Synthetic pyrethroids are widely used insecticides in both urban and agricultural environments. The use of pyrethroids is likely to increase further as the use of some popular organophosphates is restricted.

Pyrethroids display high toxicity to a wide range of aquatic organisms including invertebrates. However, due to their strong affinity to absorb to sediment and soil particles, pyrethroids are expected to partition between the solid and the dissolved phase in runoff or stream effluents. Because only the dissolved chemical concentration is considered bioavailable, the actual toxicity of pyrethroids may be regulated by the level and properties of the suspended solids and dissolved organic matter (DOM) present in runoff. However, current water quality programs require that the whole effluent is extracted and the total chemical concentration of the pyrethroids is determined. Such practices will likely result in erroneously high estimates of toxicity.

With the support of this grant, we developed a solid phase microextraction (SPME) method that offers selective detection of the dissolved concentration. We further evaluated the application of this method for biomimetic sampling. This method has been used to study the phase distribution of a number of pyrethroids in water systems containing suspended solids. We have demonstrated that in runoff effluents containing suspended solids at 100 mg/L, a significant fraction of pyrethroids was associated with the solid phase and (DOM). The freely dissolved concentration was

inversely proportional to the content of suspended particulates and DOM. Using ^{14}C -labelled compounds, we further found that bioaccumulation of pyrethroids decreased with increasing levels of suspended solids. Using EPA protocols, we showed that the acute toxicity of pyrethroids in sediment suspensions decreased with increasing levels of suspended particulates and DOM. It appears that both the amount and properties of suspended solids and DOM affect the bioavailability and toxicity of pyrethroids. The inhibitory effect of suspended solids and DOM on bioavailability and toxicity should be considered in monitoring efforts as well as in establishing water quality standards for pyrethroid compounds.

Collaborative Efforts

We have closely collaborated with a range of stakeholders in carrying out this project. Our collaborators include nursery growers in Orange and Ventura Counties, farm advisors, and regulatory agencies (e.g., SWRCB, Santa Ana RWQCB, CDPR). We have collaborated extensively with the following individuals/entities:

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Publications

Lee, S.J., J. Gan, W.P. Liu, and M.A. Anderson, Evaluation of K_d underestimation using solid phase microextraction, *Environmental Science & Technology* 37: 5597-5602, 2003

Lee, S.J., J. Gan, J.S. Kim, J.N. Kabashima, and D. Crowley, Microbial transformation of pyrethroid insecticides in aqueous and sediment phases. *Environmental Toxicology and Chemistry* 23: 1-6, 2004

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Kabashima, J.N., S.J. Lee, D.L. Haver, L. Wu, K. Goh, and J. Gan, Pesticide runoff and mitigation at a commercial nursery site, In Gan, J., P. Zhu, S.A. Aust, and A.T. Lemley (eds). *Deactivation and Detoxification of Biocides and Pesticides*. ACS Symposium Series, ACS: Washington, DC, pp. 213-230, 2004

Gan, J., S.J. Lee, W.P. Liu, D. Haver, and J.N. Kabashima, Distribution and persistence of synthetic pyrethroids in runoff sediments, *Journal of Environmental Quality* 34: 836-841, 2005

Professional Presentations

Gan, J. Underestimation of K_d measurement for hydrophobic chemicals, Annual American Society of Agronomy Meetings, November 2-6, 2003. Denver, Colorado (talk).

Gan, J., S.J. Lee, D.L. Haver, J.N. Kabashima, and L. Wu, Pesticides in nursery runoff: assessment and mitigation, Annual American Society of Agronomy Meetings, November 2-6, 2003. Denver, Colorado (poster).

Gan, J., and S.J. Lee, How persistent are those pyrethroids? SETAC 24th Annual Meeting in North America, November 9-13, 2003. Austin, TX (poster).

Gan, J., W. Yang, M.A. Irwin, and W.P. Liu, Synthetic pyrethroids: bioavailability in surface water, ACS 227th National Meeting. March 28-April 1, 2004, Anaheim, CA (talk)

Gan, J., J.N. Kabashima, D. Haver, and L. Wu, Management practices for mitigating pesticide runoff from nurseries, ACS 227th National Meeting. March 28-April 1, 2004, Anaheim, CA (invited talk)

Gan, J., Bioavailability of synthetic pyrethroids in surface water system, Chemical Society of Canada Annual Meetings, June 1, 2004, London, Canada (Invited talk).

Gan, J., and W. Yang, Bioavailability of synthetic pyrethroid insecticides in surface water, The 1st International Internal Exposure Workshop, August 21-26, 2004, Ascona, Zurich. (Poster, won best poster award).

Gan, J., Bioavailability of synthetic pyrethroids in surface streams, September 14, 2004, Mid-Atlantic Pesticide Metabolism Discussion Group Annual Dinner Meeting, Fort Washington, PA (invited feature presentation).

Gan, J., W. Yang, and W. Hunter, Chemical methods for measuring bioavailability, Southern California SETAC Annual Conference, Loyola Marymount University, Los Angeles, CA, May 20-21, 2005.

Gan, J., W. Yang, and W. Hunter, Polymer fibers to measure bioavailable concentrations, 88th Canadian Chemistry Conference and Exhibition. Saskatoon, CA, May 28-June 1, 2005.

Hunter, W., W. Yang, and J. Gan, Bioavailability of permethrin in sediments estimated with solid phase micro-extraction (SPME), Southern California SETAC Annual Conference, Loyola Marymount University, Los Angeles, CA, May 20-21, 2005. (Student poster award)

Yang, W., W. Hunter, and J. Gan, Bioavailability of synthetic pyrethroids in surface water, Southern California SETAC Annual Conference, Loyola Marymount University, Los Angeles, CA, May 20-21, 2005. (Poster)

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