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Occupational and Residential Human Exposure Assessment
Biomonitoring
Chemical Risk Assessment
Risk Management and Risk Communication

Fellow, American Academy of Toxicological Sciences, 1983-present
Fellow, American College of Toxicology, 2007
Member, American Chemical Society, 1970-present
Member, Society of Toxicology, 1975-present

Society of Toxicology, Education Award, 1986; AztraZeneca Traveling Lectureship Award, 1990 Public Communications Award, 2005

American Chemical Society, International Award for Research in Agrochemicals, 2005

University of California, Riverside, Non-Senate Distinguished Researcher Award, 2004-2005

Entomological Society of America Pacific Branch Distinguished Achievement Award in Extension, 2006

Distinguished Alumnus, Pacific Lutheran University, 2006

Outstanding Faculty Mentor Award, Environmental Toxicology Graduate Program, University of California, Riverside 2007-2008

Bob Krieger is a Cooperative Extension Toxicologist in the Department of Entomology, University, Riverside and a member of the Graduate Program in Environmental Toxicology. He holds a B.S. *cum laude* in Chemistry from Pacific Lutheran University (1967) and a Ph.D. from Cornell University (1970) where he was a student in the Department of Entomology and an NIEHS Trainee in Environmental Toxicology. Graduate study fields included toxicology, physiology, and biochemistry. He has held tenured academic appointments at U.C. Davis (1971-1980) and in the Washington-Oregon-Idaho Regional Veterinary Medical Education Program (1981-1986) where he was Professor of Veterinary and Comparative Toxicology. In 1986 he became a staff toxicologist and later Branch Chief, Worker Health and Safety, California Department of Food and Agriculture (now California EPA). Krieger served two major Washington D.C., consulting firms (1991-94) in exposure and risk assessment before returning to the University of California as an extension Toxicologist (1994-present) specializing in pesticide exposure assessment and worker health and safety. He has taught toxicology at both the undergraduate and graduate levels and received several teaching awards including the Society of Toxicology's Education Award in 1986. His research concerns the fate and effects of pesticides in humans, risk assessments, and risk communication. Current studies concern methods and techniques for determining the availability of chemical residues on surfaces, exposure biomonitoring of urban and agricultural populations that are exposed to pesticides and other chemicals.

At UCR Krieger heads the Personal Chemical Exposure Program that includes research and extension activities in urban and agricultural settings. He also headed the distinguished editorial team that produced the Hayes' Handbook of Pesticide Toxicology (2010).

Personal Chemical Exposure Program
Human Exposure Assessment in Risk Perception and Risk Management

Identification and movement of pesticides and other chemical residues from environmental compartments to children and adults. Indoor, turf, and agricultural settings have been included in our program and findings to date have led to generalized knowledge of contact-transfer processes.

In agriculture this research has supported development of exposure-based field entry times, as opposed to toxicity-based entry times that were extensively used prior to implementation of the risk assessment process. Effective field entry times require knowledge of available surface residues, accurate human pesticide exposure data, and clear definition of work tasks. Short-term, seasonal, and long-term exposures need to be considered. We will continue to investigate the relationship between surface chemical exposures including dislodgeable foliar and surface residues on turf or agricultural crops or indoor pesticide residues in homes. Transfer and human bioavailability of residues will be studied by urine biomonitoring. We expect to explore chemical transferability of chemical residues with respect to chemical (active ingredients as well as spray adjuvants) as well as from physical characteristics (absorption, particularly cuticular waxiness in the case of plants and nylon carpets). New laboratory and field methods are being developed to better understand some critical human chemical exposure issues.

Studies of indoor exposure potential of insecticides are a second major initiative of the Personal Chemical Exposure Program. Physical and chemical methods of determining chemical deposition and availability are under study. Indoor studies also permit close evaluation of environmental sampling devices (dosimeters) to assess potential exposure of adults and children. Family based studies have been a prominent part of work with organophosphorous, N-methyl carbamate, and pyrethroid insecticides. Since environmental measurements are especially critical for indoor studies, these activities continue to represent important scientific challenges that have considerable regulatory importance.

Program Staff have completed the "Tutorial on the Protection of Human Subjects Used in Research" The tutorial can be found at <http://www.ora.ucr.edu/appTutorial/TutorialClient/Introduction.asp>

Selected Publications:

Published

- Hayes' Handbook of Pesticide Toxicology. 3rd Edition. 2010. Krieger, R. I. (ed.) Academic Press/Elsevier, San Diego, CA.
- Chen, Z., F. Maartens, H. Vega, S. Kunene, J. Gumede, R. I. Krieger. 2009. 2, 2-bis(4-Chlorophenyl) acetic acid (DDA), a water-soluble urine biomarker of DDT metabolism in humans. *Int. J. Toxicol.* 28: 528-533.
- Krieger, R. I., C. Sanchez, J. Fonseca, B. Blount. 2009. Hypochlorite treatments are not a significant source of perchlorate exposure in lettuce. *J. Agric. Food Chem.* 57: 2320–2323.
- Keenan, J. J., H. Vega, R. I. Krieger. 2009. Potential exposure of children and adults to Cypermethrin following use of indoor foggers. *J. Environ. Sci. Health Part B.* 44:538-545.
- Zhang, X., J.H. Driver, Y. Li, J.H. Ross, and R.I. Krieger. 2008. Dialkylphosphates (DAPs) in Fruits and Vegetables Can Confound Biomonitoring in Organophosphorus Insecticide Exposure and Risk Assessment. *J. Agric. Food Chem.* 56: 10638-10645.
- Williams R. L., C. E. Bernard, M. Bigelow-Dyk, J. H. Ross, R. I. Krieger. 2008. Measurement of transferable chemical residue from nylon carpet using the California Roller and a new Mega-California Roller. Submitted to *J. Environ. Science Health Part B.* 43: 675-679.
- Krieger, R. E. 2008. Aldrin Epoxidation and Dihydroisodrin Hydroxylation As Probes Of *In Vivo* and *In Vitro* Oxidative Metabolic Capability Of Some Caterpillars. *Pest Management Science. Pest Manag. Sci.* 64: 622-627.
- Sanchez, C. A., B. C. Blount, L. Valentin-Blasini, S. M. Lesch, R. I. Krieger. 2008. Perchlorate in the Feed-Dairy Continuum of the Southwestern United States. *J. Agric. & Food Chem.* 56: 5443-5450.
- Sanchez, C. A., L. Barraja, B. C. Blount, C. Scrafford, L. Valentin-Balsini, K. M. Smith, R. I. Krieger. 2008. Perchlorate Exposure from Food Crops Produced in the Lower Colorado River Region. *J. Exp. Sci. Environ Epidemiol.* 5: 1-10.
- Woodrow, J. E., J. N. Seiber, J. S. LeNoir, R. I. Krieger. 2008. Determination of MITC in Air Downwind of Fields Treated with Metam Sodium by Sub-Surface Drip Irrigation. *J. Agric. Food Chem.* 56: 7373-7378.
- Sanchez, C. A., B.C. Blount, L. Valentin-Blasini, R. I. Krieger. 2007. Perchlorate, Thiocyanate, and Nitrate in Edible Cole Crops (*Brazzica sp.*) Produced in the Lower Colorado River Region. *Bull. Environ Contam Toxicol.* 79: 655-659.
- Sanchez C.A., K. S. Crump, R. I. Krieger, N. R. Khandaker, J. P. Gibbs. 2006. Perchlorate and nitrate in leafy vegetables of North America. *Environ. Science Tech.* 39: 9391-9397

- Sanchez, C., R. I. Krieger, N. R. Khandaker, L. Valentin-Blasini, B. C. Blount. 2006. Potential Perchlorate Exposure from Citrus sp. Irrigated with Contaminated Water. *Analytica Chimica Acta*. 567: 33-38.
- Sanchez, C. A., R. I. Krieger, L. Valentin-Blasini, B. C. Blount, and N. R. Khandaker. 2006. Perchlorate Accumulation and Potential Exposure from Durum Wheat Irrigated with Colorado River Water. *Journal of ASTM International*. Online Vol 3: 7.
- Barton, H. A., T. P. Pastoor, K. Baetcke, J. E. Chambers, J. Diliberto, N. G. Doerrer, J. H. Driver, C. E. Hastings, S. Iyengar, R. Krieger, B. Stahl, C. Timchalk. 2006. The acquisition and application of absorption, distribution, metabolism, and excretion (adme) data in agricultural chemical safety assessments. *Critical Reviews in Toxicology*, 36: 9-35.
- Sanchez, C. A., R. I. Krieger, N. Khandaker, R. C. Moore, K. C. Holts, and L. L. Neidel. 2005. Accumulation and perchlorate exposure potential of lettuce produced in the lower Colorado River Regions. *J. Agric. & Food Chem.* 53: 5479-5486
- Dowling, K. C., L. E. Blanco R., I. Martinez M., A. Aragon B., C. E. Bernard, and R. I. Krieger. 2005. Urinary 3, 5, 6-trichloro-2-pyridinol Levels of chlorpyrifos applicators and small farm families in Nicaragua. *Bull. Environ. Contam. Toxicol.* 74 : 380-387.
- Gerry, A. C., X. Zhang, G. Leng, A. D. Inman, and R. I. Krieger. 2005. Low pilot exposure to pyrethrin during ultra low volume (ULV) aerial insecticide application for control of adult mosquitoes. *Journal of the American Mosquito Control Association*. 21: 291-295.
- Krieger, R. I. 2005. Reviewing some origins of pesticide perceptions. *Outlooks on Pest Management*. 16: 244-248.
- Gerry, A.C., X. Zhang, T. Walker, S. Frederickson, M. Metzger, R. Hu, R. I. Krieger. 2005. Worker exposure to diazinon during flea control operations in response to a plague epizootic. *Bull. Environ. Contam. Toxicol.* 74 (2): 391-398.
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- Krieger, R. I., T. M. Dinoff, and X. Zhang. 2003. Octachlorodipropyl Ether (S-2) Mosquito Coils are Inadequately Studied for Residential Use in Asia and Illegal in the United States. *Environmental Health Perspectives*. 111: 1439-1442.
- Williams, R. L., C. E. Bernard, and R. I. Krieger. 2003. Human exposure to indoor residential cyfluthrin residues during a structured activity program. *Journal of Exposure Analysis and Environmental Epidemiology*. 13: 112-119.
- Duggan, G. Charnley, W. Chen, A. Chukwudebe, R. Hawk, R. I. Krieger, J. Ross, and C. Yarborough. 2003. Di-alkyl phosphate biomonitoring data: assessing cumulative exposure to organophosphate pesticides. *Regulatory Toxicology and Pharmacology* 37: 382-395.

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- Williams, R.L., C.E. Bernard, R.I. Krieger. 2001. Child-like Mannequin for Observation and Measurement of Spray Drift Deposition for Pesticide Exposure Assessment. *Bull. Environ. Contam. Toxicol.*, 67: 179-186.
- Krieger, R. I., C. E. Bernard, T. M. Dinoff, L. Fell, T. Osimitz, J. H. Ross, and T. Thongsinthusak. 2000. Biomonitoring and whole body cotton dosimetry to estimate potential human dermal exposure to semivolatile chemicals. *J. Exposure Analysis & Environ. Epidemiol.* 10: 50-57.
- Krieger, R. I. and T. M. Dinoff. 2000. Captan Fungicide Exposures of Strawberry Harvesters Using THPI as a Urinary Biomarker. *Arch. of Environ. Contam. and Toxicol.* 38: 398-403.

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- Thongsinthusak, T., J. H. Ross, S. G. Saiz and R. I. Krieger. 1999. Estimation of Dermal Absorption Using the Exponential Saturation Model. *J. Regulatory Toxicol. and Pharm.* 29: 37-43.