

Veith G D, DeFoe D L & Bergstedt B V. Measuring and estimating the bioconcentration factor in fish. *J. Fish. Res. Board Can.* 36:1040-8, 1979.
[US Environmental Protection Agency, Environmental Research Laboratory—Duluth, MN]

A method was developed to measure the bioconcentration factor of organic chemicals in fish as an assessment of chemical potential for bioaccumulation in the environment. Results of early testing were used to formulate a structure-activity to predict bioconcentration factors. [The *SCI*[®] indicates that this paper has been cited in more than 245 publications.]

The Black Magic of Chemical Residues

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The *Silent Spring*¹ decade of the 1960s saw many examples of chemical intoxication of birds, fish, and wildlife. Joseph Hickey, one of my great mentors at the University of Wisconsin, Madison, challenged me to find out why some pesticides accumulated as residues and others did not. In Duluth, Doug Kuehl and I were identifying chemical residues in fish from US rivers using some wonderful new gas chromatography/mass spectrometry (GC/MS) technology (now regarded as the Edsels of MS). We noticed that fish that had only a few chemicals accumulated in the body often were living in rivers that had hundreds of chemicals in the water. We began to build a counter-current extractor model of fish gills to simulate bioconcentration in fish.

EPA experience at the time was largely focused on the toxic effects of heavy metals and some pesticides, with little appreciation for the relevance of residues. The proposal that residues might result from simple chemical thermodynamics and physiological kinetics was portrayed as veiled black magic. While EPA was establishing a regulatory agenda for toxic chemicals, scientists from these same chemical companies were working with the Duluth laboratory to develop sensible control strategies. Dean Branson and Gary Blau from Dow shared

with us their preliminary work on a chemical bioconcentration model for trout. In 1975, at an informal workshop on quantitative structure-activity relationship (QSAR) and bioconcentration, held in Burlington, Ontario,² we shared the research needed for a cost-effective regulation. This meeting attracted Valdo Zitho from Environment Canada, Al Leo from Pomona, Rich Kimerla from Monsanto, and many others.

I emphasize cost-effectiveness because there is a tendency to regulate chemicals uniformly by administrative brute force. When the first bioconcentration methods emerged, the cost was about \$10,000 per test. Some at EPA advocated this test for all new chemicals (approximately 30 per week) and for many of the 50,000 chemicals in commerce. We asserted that less than 15 percent of the chemicals posed residue hazards and that we could develop a reliable method of forecasting which chemicals should be tested. Rich Purdy (now at 3M Company), Leo, and I worked on improving the calculation of octanol/water partition coefficients, which were thought to correlate with the bioconcentration factor. At Duluth, Dave L. DeFoe, a gifted experimentalist, and Barbara V. (Bergstedt) Vieux, an ornithologist and the only US woman expert in advanced ZAP-MS technology, began years of testing in our laboratory. The combined results not only evaluated test methodology, but also confirmed the expectation that test results could be predicted from chemical structure.

The resultant paper was rejected by several US journals for lack of relevance. Skeptics of QSAR predictions concluded that "residues may be predictable, but you will never predict toxicity." Of course, this skepticism began to fade with the work of Joop Hermans and supporting articles by H. Konemann,³ and Dan J. Call, Larry T. Brooke, and myself.⁴ The *Classic* paper was the springboard for other papers as well as cost-effective regulations in the US and Europe. Presumably, the relevance to risk assessments for chemicals in the environment accounts for the citations.

1. Carson R. *Silent spring*. Boston, MA: Houghton Mifflin, 1962. 368 p. (Cited 310 times.)

2. Veith G D & Konsewicz D, eds. Structure-activity correlations in studies of toxicity and bioconcentration with aquatic organisms. Symposium proceedings. International Joint Commission. Windsor, Ontario. 1975. 347 p.

3. Konemann H. Quantitative structure-activity relationships in fish toxicity studies. *Toxicology* 19:209-21, 1981.

4. Veith G D, Call D J & Brooke L T. Structure-toxicity relationships for the fathead minnow, *Pimephales promelas*; narcotic industrial chemicals. *Can. J. Fisheries Aquat. Sci.* 40:743-8, 1983. (Cited 105 times.)

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