

## Inclusion of Pesticide Transformation Products Is Key to Estimating Pesticide Exposures and Effects in Small U.S. Streams

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### Abstract

Improved analytical methods can quantify hundreds of pesticide transformation products (TPs), but understanding of TP occurrence and potential toxicity in aquatic ecosystems remains limited. We quantified 108 parent pesticides and 116 TPs in more than 3700 samples from 442 small streams in mostly urban basins across five major regions of the United States. TPs were detected nearly as frequently as parents (90 and 95% of streams, respectively); 102 TPs were detected at least once and 28 were detected in >20% samples in at least one region—TPs of 9 herbicides, 2 fungicides (chlorothalonil and thiophanate-methyl), and 1 insecticide (fipronil) were the most frequently detected. TPs occurred commonly during baseflow conditions, indicating chronic environmental TP exposures to aquatic organisms and the likely importance of groundwater as a TP source.

Hazard quotients based on acute aquatic-life benchmarks for invertebrates and nonvascular plants and vertebrate-centric molecular endpoints (sublethal effects) quantify the range of the potential contribution of TPs to environmental risk and highlight several TP exposure–response data gaps. A precautionary approach using equimolar substitution of parent benchmarks or endpoints for missing TP benchmarks indicates that potential aquatic effects of pesticide TPs could be underestimated by an order of magnitude or more.

