Research Brief 179: Scaling up from Local Deterministic Measurement to a Regional Probabilistic Model

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Background:

Contaminants on the surface of the soil can be transported into waterways by storm events, threatening the health of aquatic ecosystems and safety of human drinking water. In an effort to understand the fate of both accidental and intentional surface contaminants, and to minimize the downstream threat to water quality and aquatic organisms, Dr. Thomas Young at the University of California-Davis SRP is working to generate predictive models for the movement of surface contamination mobilized by storm events. Dr. Young is investigating the runoff-mediated movement of organics from soil surfaces by examining the mobility of herbicides along roadways.

Advances:

This approach takes advantage of the detailed information about pesticide use in the California Department of Pesticide Regulation's database. Dr. Young coupled the extensive application statistics including location, timing, and types/amounts of herbicides used with meteorological data including frequency and intensity of storm events to develop predictive models for the movement of surface contaminants made mobile by precipitation. He analyzed the transport rates considering different rainfall events, runoff quantities, site configuration, and variability of herbicide properties.

In 2007, approximately 80,000 miles of California roadsides were sprayed with 3.4 million pounds of herbicides and adjuvants (additives that modify the action of an agrichemical) for weed control.

Dr. Young's research group combined field data on herbicide runoff in multiple storm seasons at two northern California sites with laboratory sorption and desorption measurements using materials from the monitoring sites. They then developed a deterministic mathematical model of the process (i.e., the model produces one output concentration for a particular set of input conditions) specifically for predicting transport and fate of chemicals in overland flow. The model included four modules: surface flow, sub-surface flow, percolation, and chemical transport.

This research led to several findings of interest that relate to the behavior of surface contaminants at hazardous waste sites:

- The majority of the herbicide transport occurred in a dissolved form (i.e., the contaminants were not particle bound).
- Timing is critical. The longer the interval between application and storm events, the lower the propensity for the herbicide to move from the point of application.
- In most cases, a simple linear equilibrium adsorption-desorption model could account for the transport of the herbicides in the runoff.
- Vegetated surfaces transferred lower levels of herbicides to runoff water compared to areas that lacked vegetation or had reduced vegetation.

The major advance of this research is the stochastic application (i.e., accounts for probability of different possible outcomes) of a physically-based, one dimensional, mathematical model to a regional scale. By comparing the results of environmental end points of these herbicides, the frequency of potential toxic outcomes was calculated for more than 30 different herbicides. The results will be useful in guiding decisions about the relative ecological risks of different contaminants, the effect of initial contamination levels, and in understanding the relative impacts of regional precipitation patterns, site geometries, and soil characteristics.

Significance:

This work provides a paradigm for estimating the probability of adverse ecological effects for a wide range of different chemicals in surface runoff, especially from a site with diverse contaminated zones. The approach employed here can be used at existing hazardous waste sites to estimate ecological risks of surface runoff from contaminated soils and, in the longer term can be used to guide selection of replacements to superfund chemicals that will have significantly reduced ecological impacts. Although the ecological endpoint employed in this research was acute aquatic toxicity, this approach is also applicable to other environmental endpoints being investigated by SRP researchers, such as endocrine disruption.

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To learn more about this research, please refer to the following source:

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