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Exposure assessment tools to estimate pesticide concentrations in surface water and groundwater in paddy rice systems: a case study of northern Lomellina, Italy

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Abstract
Widespread concerns about the environmental impact of plant protection products have highlighted the need for predictive exposure modelling and environmental risk assessment within the European regulatory framework. Estimating pesticide concentrations in paddy rice systems is particularly challenging due to the unique hydrological conditions associated with flooded cultivation. Among the available tools, the numerical model RICEWQ is considered the most most suitable to simulate pesticide fate in rice paddies. In this study, RICEWQ was coupled with RIVWQ to assess exposure in riverine systems and with VADOFT to evaluate vertical transport in underlying soil layers. The environmental fate of six widely used herbicides in the Lomellina rice-growing area (Lombardy Region, northern Italy) was simulated under three irrigation strategies across four predominant soil units. Predicted peak concentrations in receiving canal water remained below regulatory acceptable concentrations (RACs) and were generally consistent with recent monitoring data from ARPA-Lombardia (i.e. agency responsible for the environmental monitoring in the Lombardy region). However, annual average groundwater concentrations at 1 m depth occasionally exceeded the drinking water limit of 0.1 µg/L in more vulnerable soils. Regression analyses identified infiltration rates and water management practices as the main drivers influencing groundwater variability. Numerical models provide reliable exposure estimates in complex rice-growing systems, although their performance is constrained by uncertainties in parameterization, which must be carefully considered when applying these tools.

Keywords: rice paddy, pesticide exposure, predicted environmental concentration, exposure modeling, pesticide risk assessment