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Process based groundwater vulnerability assessment tool for pesticides

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Pesticides are increasingly detected in shallow groundwater and are one of the main causes of the poor chemical status of phreatic groundwater bodies. To protect valuable groundwater resources there is a need for receptor specific groundwater vulnerability information. Receptors could be specific groundwater wells, rivers or even entire phreatic aquifers. Based on the pesticide vulnerability information, site specific mitigating actions can be taken to efficiently protect the receptors in the groundwater system.

A flexible tool that performs a receptor and substance specific vulnerability assessment was developed. The tool uses a fully process-based approach for calculating the vulnerability of a receptor for a specific pesticide. The user specifies the application dose and time of a specific pesticide after which the tool simulates the transport of the pesticide through the unsaturated and saturated zone to the receptor. The vulnerability assessment tool is developed in the Python programming language. The tool uses a series of 1D vertical leaching models for simulating the transport of pesticides in the unsaturated zone. The 1D models are parameterized for Flanders in 1434 unique combinations of soil properties, climate and groundwater depth. The pesticide properties for which the leaching through the unsaturated zone is simulated by the model should be specified by the user. The transport of pesticides through the saturated zone is simulated using a flowline calculation from the top of the aquifer to the receptor. The flowline calculation uses an analytical solution of the advection-diffusion equation and takes into account sorption and if necessary first order decay. The flow path characteristics for the saturated zone are obtained from particle tracking output files (e.g. MODPATH/MODFLOW) for the specific site that have to be provided by the user.

The tool returns maps of the recharge area of the receptor specifying: (1) the maximum concentration of the pesticide reaching the receptor, (2) percentage of the applied mass reaching the receptor and (3) the time it takes for the pesticide to reach the maximum concentration at the receptor. This information can be used for selecting the most appropriate measures to protect the groundwater quality at the receptor, such as in source water protection plans for drinking water wells.