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Assessing glyphosate movement through different agricultural systems with a shallow water table: insights from an inverse dual permeability model

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The movement dynamics of glyphosate (GLY) in soil can be highly complex and challenging to predict, because its high water solubility and strong propensity to soil particle adsorption can interact with agricultural management practices, e.g. tillage operations and water table management. This can make GLY i) sensitive to nonuniform leaching via preferential flow paths into the groundwater before it can degrade, ii) difficult to model according to uniform flows. The aim of this study was to understand GLY dynamics in different agricultural systems of the low-lying Venetian plain, by calibrating a dual permeability model embedded in HYDRUS-1D using a series of GLY experimental data that were collected in the field, and compare it with a dual porosity mobile-immobile approach. Experimental data came from eight drainable lysimeters, where two shallow water table depths (60 cm and 120 cm deep) were compared in conventional (CV) and conservation agriculture (CA) systems as representative of the low-lying Venetian plain conditions (NE Italy). On May 2019, GLY and a tracer (KBr) were applied on bare soil (in CV) and rye that was used as a cover crop, in CA. After the distribution, soil (0-5, 5-15 cm deep) and soil-pore water (15, 30, 60 cm deep) samples were collected for 48 days to follow solutes dynamics. At the same depths, soil moisture and matric potential were monitored using TDR probes and electronic tensiometers. An automated system modulated the suction through matric potential readings combined with an electronic vacuum regulator. The HYDRUS 1-D software package was employed for inverse modelling of soil properties, first through parameterization and matric potential results, while solute movement parameters were calibrated based on GLY and KBr results from soil and water samples. Experimental results showed that GLY was found at different depths, especially soon after its distribution as dependent on intense rainfall events. The MIM model failed to predict any GLY movement, due to its high adsorption coefficient that hindered any GLY exchange between the immobile and mobile phases. In fact, experimental observations revealed that a preferential flow occurred down to the deepest layers (60 cm deep), even in the presence of poorly structured soil and irrespective of both the groundwater level and the cultivation system. In contrast, the dual permeability model provided a more accurate description of GLY dynamics in soil, successfully predicting the observed bypass flow timing experiment. Therefore, dual permeability model seems crucial for describing GLY dynamics in agroecosystems, enabling more accurate predictions of its potential pathways.