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Modeling water infiltration and pesticides transport in unsaturated zone of a sedimentary aquifer

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Groundwater quality monitoring has become an important environmental, economic and community issue since increasing needs drinking water at the same time with high anthropic pressure on aquifers. Leaching of various contaminants as pesticide into the groundwater is closely bound to water infiltration in the unsaturated zone which whom solute transport can occur. Knowledge's about mechanisms involved in the transfer of pesticides in the deep unsaturated zone are lacking today. This study aims to evaluate and to model leaching of pesticides and metabolites in the unsaturated zone, very heterogeneous, of a fluvio-glacial aquifer, in the South-East of France, where contamination of groundwater resources by pesticides is frequently observed as a consequence of intensive agricultural activities. Water flow and pesticide transport were evaluated from column tests under unsaturated conditions and from adsorption batch experiments onto the predominant lithofacies collected, composed of a mixture of sand and gravel. A maize herbicide, S-metolachlor, applied on the study site and worldwide and its two major degradation products (metolachlor ethanesulfonic acid and metolachlor oxanilic acid) were studied here. A conservative tracer, bromide ion, was used to determine water dispersive parameters of porous media. Elution curves were obtained from pesticide concentrations analyzed by an ultra-performance liquid chromatography system interfaced to a triple quadrupole mass spectrometer and from bromide concentrations measured by ionic chromatography system. Experimental data were implemented into Hydrus to model flow and solute transfer through a 1D profile in the vadose zone. Nonequilibrium solute transport model based on dual-porosity model with mobile and immobile water is fitting correctly elution curves. Water dispersive parameters show flow pattern realized in the mobile phase. Exchanges between mobile and immobile water are very limited. Because of low adsorptions onto fluvio-glacial deposits, retention of S-metolachlor and its ionic metabolites is low in column tests and high mobility was observed meaning these molecules are prone to reach groundwater.