Assessing the multiple effects of dissolved organic matter on the transport of organic pollutants in subsoil horizons through a modular modeling approach

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Abstract :

The role of dissolved organic matter (DOM) in the transport of trace organic pollutants through the soil profile remains controversial. Several studies reported enhanced transport for nonpolar pesticides and other pollutants such as pharmaceuticals (e.g., Borgman & Chefetz 2013). It is generally hypothesized that DOM modifies the sorption properties of the contaminants through co-sorption and/or cumulative sorption (Totsche et al. 1997). Co-transport with DOM can also enhance the mobility of pollutants (Chabauty et al. 2016). Other authors reported little effect of DOM on both sorption or desorption of herbicides (e.g., Barriuso et al. 2011). To help elucidating the multiple roles of DOM, we developed the PolDOC model implemented in the VSoil modeling platform of INRAE. We took advantage of the modularity of the platform to couple available 1D water flow and solute transport models with novel reactivity modules for organic pollutants and DOM. Indeed, sink/source terms in the transport equation have been used to calculate the interactions between pollutants, DOM and the soil solid phase.The model was designed to simulate the transport of organic pollutants in intact soil cores sampled in the Bt horizon of a cultivated Albeluvisol to which either a synthetic soil solution without DOM (SYNTH), a soil solution extracted from the top horizon (CONTROL) or a soil solution extracted from the top horizon of a neighbour plot receiving sewage sludge and green waste compost (SGW) were applied (Chabauty et al., 2016). In PolDOC, the organic pollutants can be transported either free or associated with DOM. To describe the multiple roles of DOM in the transport of organic pollutants we first simplified the wide spectrum of organic molecules which constitute DOM and distinguished two types of DOM with different reactivity: DOMBt produced by depolymerization of the organic matter in the Bt soil horizon, and DOMSURF, produced by depolymerization of the organic matter of the surface horizon.The model was used to simulate the transport of both DOM types and three different organic pollutants: isoproturon (ISO), a mobile herbicide, epoxiconazole (EPX), a moderately mobile fungicide and sulfamethoxazole (SMX), a mobile antibiotic. Since pollutants are applied at the soil surface, we considered that organic pollutants will be more prone to interact with DOMSURF, which is rich in phenolic compounds. Physical non-equilibrium transport conditions were identified and quantified with PolDOC. Model showed that the Bt horizon acted as a sink to partly retain DOMSURF. While differences in ISO and SMX transport could be explained by different sorption reactivity with the soil solid phase, the increased leaching of EPX in presence of DOMSURF required the activation of co-transport with DOMSURF.

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