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Sensitivity analyses of a colloid-facilitated contaminant transport model for unsaturated heterogeneous soil conditions.

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Certain contaminants may travel faster through soils when they are sorbed to subsurface colloidal particles. Indeed, subsurface colloids may act as carriers of some contaminants accelerating their translocation through the soil into the water table. This phenomenon is known as colloid-facilitated contaminant transport. It plays a significant role in contaminant transport in soils and has been recognized as a source of groundwater contamination. From a mechanistic point of view, the attachment/detachment of the colloidal particles from the soil matrix or from the air-water interface and the straining process may modify the hydraulic properties of the porous media. Šimůnek et al. (2006) developed a model that can simulate the colloid-facilitated contaminant transport in variably saturated porous media. The model is based on the solution of a modified advection–dispersion equation that accounts for several processes, namely: straining, exclusion and attachement/detachement kinetics of colloids through the soil matrix. The solutions of these governing, partial differential equations are obtained using a standard Galerkin-type, linear finite element scheme, implemented in the HYDRUS-2D/3D software (Šimůnek et al., 2012). Modeling colloid transport through the soil and the interaction of colloids with the soil matrix and other contaminants is complex and requires the characterization of many model parameters. In practice, it is very difficult to assess actual transport parameter values, so they are often calibrated. However, before calibration, one needs to know which parameters have the greatest impact on output variables. This kind of information can be obtained through a sensitivity analysis of the model. The main objective of this work is to perform local and global sensitivity analyses of the colloid-facilitated contaminant transport module of HYDRUS. Sensitivity analysis was performed in two steps: (i) we applied a screening method based on Morris' elementary effects and the one-at-a-time approach (O.A.T); and (ii), we applied Sobol's global sensitivity analysis method which is based on variance decompositions. Results illustrate that ψm (maximum sorption rate of mobile colloids), kdmc (solute desorption rate from mobile colloids), and Ks (saturated hydraulic conductivity) are the most sensitive parameters with respect to the contaminant travel time. The analyses indicate that this new module is able to simulate the colloid-facilitated contaminant transport. However, validations under laboratory conditions are needed to confirm the occurrence of the colloid transport phenomenon and to understand model prediction under non-saturated soil conditions. Future work will involve monitoring of the colloidal transport phenomenon through soil column experiments. The anticipated outcome will provide valuable information on the understanding of the dominant mechanisms responsible for colloidal transports, colloid-facilitated contaminant transport and, also, the colloid detachment/deposition processes impacts on soil hydraulic properties.

References:

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