Model-based interpretation of tracer tests in fractured limestone and clayey till

Mosthaf, Klaus; Jørgensen, Peter; Lanters, Chloe Annelies; Badawi, Nora; Aamand, Jens; Rolle, Massimo

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3D model-based interpretation of tracer tests in large undisturbed columns from clayey till

Content

Large undisturbed columns (LUC) provide the possibility of well-controlled laboratory experiments of macroporous and fractured media to investigate transport pathways and the risk of pesticide leaching to the groundwater. We have conducted several flow and solute transport tests in large undisturbed columns, which were excavated from an agricultural field site in Denmark with a clayey till geology. Hydraulic tests were performed on the columns to determine the main hydraulic properties. A series of solute transport tests was performed under in-situ pressure and temperature conditions. First a mixture of different pesticides was injected, followed by an injection of a conservative bromide tracer and finally by an injection of the color tracer brilliant blue, all under constant flow conditions. After the brilliant-blue tracer injection, the column was opened and segmented, which allowed to map the location of conductive fractures and to inspect the column interior.

Distinct macropores and fractures could be identified as major transport pathways, with a strong hydraulic conductivity contrast between fractures and matrix. Several visible fractures contained iron precipitate, that blocked parts of the fractures and channeled the flow in the open parts. Based on the mapping and on the characterization of the clayey till matrix, a detailed 3D discrete fracture model was setup to simulate the flow and solute transport in the column considering both the preferential flow through the fractures and the interaction with the clayey-till matrix. The pesticides used in the flow-through experiments (bentazone, MCPA, tebuconacole) have different sorption and degradation characteristics, which were analyzed in the laboratory and included in the model simulations. The model allowed interpreting the resulting breakthrough curves of the pesticides and of the bromide tracer in the LUC setups taking into account the physical and biogeochemical processes controlling the transport and breakthrough of the different compounds. Furthermore, the influence of various parameters on solute transport through macroporous fractured clayey till could be analyzed with a sensitivity study using the calibrated model.

References

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Primary author(s) : Dr. MOSTHAF, Klaus (Technical University of Denmark); Dr. JØRGENSEN, Peter (PJ Bluetech); LANTERS, Chloe (DTU Environment); Dr. BADAWI, Nora (Geological Survey of Denmark and Green-

land); Prof. AAMAND, Jens (Geological Survey of Denmark and Greenland); Prof. ROLLE, Massimo (Technical University of Denmark)

Presenter(s) : Dr. MOSTHAF, Klaus (Technical University of Denmark)

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