Abstract

RNDr. Mihala, Patrik: Solution of direct and inverse problems for transport of water and heat in porous media. PhD thesis, Comenius University. Faculty of Mathematics, Physics and Informatics, Department of Mathematical Analysis and Numerical Mathematics. Bratislava : FMFI UK, 2021, 81 p.

In this work we deal with the coupled problem of water flow, contaminant transport in the water, adsorption of the contaminant, heat transport in the water, heat conduction in the matrix and their heat exchange in a cylindrical porous media. We extend the model with the viscosity and density dependence on temperature and concentration in the water, which influence hydraulic permeability. We also consider the influence of adsorbed contaminant on the pore structure and investigate the influence of heat expansion of the infiltrated water.

The water flow is governed by Richardson's nonlinear differential equation, based on the empirical van Genuchten-Mualem model and it is dependent on heat and contaminant transport. The heat transport in the water is strongly dependent on the flow of water and also it is dependent on the heat conduction in the matrix. Contaminant transport is also dependent on water flow and affects the adsorption of the contaminant into the porous media. The adsorbed contaminant changes the structure of the porous material, which affects the water flow.

Numerical modelling includes direct and inverse problem solution, where we determine capillary parameters from the van Genuchten-Mualem empirical model, hydraulic permeability of saturated porous media, transverse and longitudal dispersion, heat transfer coefficient in pores and heat conductivity coefficient of porous medium in matrix, coefficient adsorption rates and adsorption isotherm coefficients. The realisation of the laboratory experiment requires only non-invasive and easily doable measurements of a three-dimensional cylinder-shaped sample.

In semidiscretization in time, we also prove the existence of a weak solution of water flow, followed by a complex model with Lipschitz-continuous data with respect to time and proof of the weak solution existence of the strongly coupled regularized complex model.