EGU22-4962
https://doi.org/10.5194/egusphere-egu22-4962
EGU General Assembly 2022

Shrinkage-swelling effect on mass transfer through a pore-scale model of the biopore - matrix interface coupling Discrete Element and Finite Volume

Luis Alfredo Pires Barbosa and Horst H. Gerke

Biopore walls are often coated with exudates and finer soil particles such that the soil in the vicinity displays altered hydro-mechanical properties resulting in distinct wettability, permeability and diffusivity when compared to the soil matrix. The mechanical properties in the coating surface (i.e. stiffness and pore structure) may change rapidly during wetting or drying, thus affecting the biopore-matrix mass exchange of water and solutes during preferential flow and local non-equilibrium dynamics.

Since the combined effects of hydro-mechanical properties on the soil structure dynamics are still poorly explored, we developed a cohesive structural model of the biopore - soil matrix interface and varied particle size and stiffness (i.e. Young's modulus) in Discrete Element Method (DEM). Pore Finite Volume (PFV) was coupled in order to simulate water and air phases during pore scale drainage in 3D. Thus, the model take into account structural responses (i.e. deformations and stresses) during the change from saturated to funicular state. Considering water tension surface constant (0.0728 Pa) and the spherical particles perfectly wettable, four coated surfaces were simulated using a combination of particle radius of 0.1 and 0.2 mm and Young's modulus of 700 GPa and 1100 GPa. The soil matrix particle properties were constant with radius of 0.3 mm and Young's modulus of 700 GPa. Lateral drainage was simulated by decreasing the pressure head at the external coated surface, then the air phase invaded soil matrix in direction to the coated area. The retention curve showed higher dependence on particle size rather than particle stiffness. Simulated drainage started relatively slow followed by a rapid saturation decrement. For smaller particles with coated surfaces, the change from slow to rapid drainage was observed twice, for the soil matrix and for coated biopore surfaces. The shrinkage behavior was linear during slow drainage followed by swelling effect in rapid saturation decrement. With the combination of smaller particles and higher Young's modulus, the plastic deformation and water retention was higher. This coupled effect of heterogeneous mechanical properties on shrinkage-swelling dynamic of biopore-matrix mass exchange bring about a new approach for more complex and realistic models.