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The experimental investigation of heat transport and water infiltration in granular packed bed due to supplied hot water from the top: Influence of supplied water flux, particle sizes and supplied water temperature

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ABSTRACT

In the present study an experimental investigation of heat transport and water infiltration in granular packed bed (unsaturated porous media) due to supplied water flux is carried out. The study is focus on the one-dimensional flow in a vertical granular packed bed column assuming local thermal equilibrium between water and particles at any specific space. This experimental study described the dynamics of heat transport and water infiltration in various testing condition. Experimentally, the influences of particle sizes, supplied water flux and supplied water temperature on heat transport and water infiltration during unsaturated flow are clarified in details. The results showed that the granular packed bed with larger particle size results in faster infiltration rate and form a wider infiltration depth. Furthermore, the increase of the supplied water flux and supplied water temperature corresponds to faster infiltration rate, but the results not linearly related to the interference between the heat transport and hydrodynamics characteristics in granular packed bed.

1. Introduction

Water infiltration is an important process in many fields such as in the fields of hydrology, soil science, agriculture, civil engineering, and chemical engineering. Infiltration characteristics of water are of prime interest for a variety of concerns, including water conservation, flooding, runoff, erosion, recovery of isothermal energy, temperature control of soil and food preservation process. The infiltration of water is affected by several intrinsic and extrinsic factors. The intrinsic factors affecting the infiltration of water are the hydraulic conductivity function, water retention characteristics and porosity of media. The extrinsic factors mainly refer to climatic conditions, such as water flow pattern, ambient temperature, water flow rate and surface tension.

In the past few decades, the infiltrations of water have been studied by several researchers. Abriola and Pinder [1] proposed an infiltration model of porous media contamination by organic compounds. And they were considered the effects of matrix and fluid compressibilities, phase composition and mechanism of driving forces, i.e., capillarity, diffusion and dispersion. Stauffer and Dracos [2] presented the experimental and numerical study of water and solute infiltration in layered porous media which restricted to two-dimensional flow in a vertical plane. They indicated the relation between capillary pressure and degree of saturation. Haverkamp et al. [3] compared the numerical simulation models for one -dimensional infiltration. They reported that the implicit schemes with implicit, or explicit evaluation of the hydraulic conductivity and water capacity functions appear to have the widest range of applicability for predicting water movement in soil with both saturated and nonsaturated regions. Wang Quan-Jiu et al. [4] reported an analytical solution for one-dimensional water infiltration and redistribution in unsaturated soil. Their results showed that the model is convenient and simple to use for predicting soil water movement without evaporation. Nevertheless, a few experimental of large-scale infiltration have been reported by Haim Gvirtzman et al. [5], Kulongoski and Izbicki [6] and Zheng Xiuqing et al. [7].

The excellent reviews concerning problem of heat and mass transport in porous media have been performed by Aoki et al. [8]. Ratanadecho et al. [9–13], Ying Ma et al. [14], Henry and Smith [15], Binning and Celia [16] and Parlange [17].

Although water infiltration processes have been studied actively for several decades, relatively few study reports the problem of heat transfer in granular packed bed coupled with unsaturated flow systematically, especially considering the effects of particle sizes, supplied water flux and supplied water temperature. This work is extended from the work of Aoki et al. [8] and carried out on experimental work for analysis of heat transport and water infiltration in granular pecked bed in several testing conditions. The purpose of this work is to study the influences of the particle

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