

Colloid transport in a quasi-saturated porous media

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Colloidal particles in soils have been considered as one of the transport carriers for contaminants through groundwater (saturated zone). In natural soil system, repeated wetting-drying cycles often leads to entrapped air in the pores of a water-saturated zone, namely, quasi-saturated condition. However, there are few studies on colloidal transport process in quasi-saturated condition. Therefore, studying the colloidal transport in such quasi-saturated condition is important to understand the phenomenon of colloidal migration in the environments. In this study, we aimed to investigate the effects of entrapped air on colloid transport in porous media based on one-dimensional column experiments. We also characterized entrapped air in the porous media by X-ray CT measurements.

Two different sand columns (1. i.d. 0.9-cm, height 10-cm, 2. i.d. 5-cm, height 10-cm) were prepared for X-ray CT measurements and column transport experiments, respectively. Columns repacked with Toyoura sand were completely water-saturated by applying degassed water to the dry-sand repacked column under vacuum condition. The soil water was drained by applying a suction of 70-cm H₂O to the column. By hanging water table, the sand columns were then re-saturated by immersing them in water tank, resulting in quasi-saturated sand columns. In the X-ray CT measurements, the sand column was scanned by X-ray CT device (Metrotom 1500, Carl Zeiss) with spatial resolution of 11.3 micron. In the column transport experiments, the suspension of silica particles (SL) with a diameter of 100 nm in diameter was injected to the columns under saturated and quasi-saturated condition at a constant flow rate. Effluents were collected periodically to measure the turbidity, which represents SL concentrations.

X-ray- CT measurements and subsequent CT image analysis showed the decreased fraction of entrapped air in pore volume and the increased fraction of smaller entrapped air at lower part of the column. Pore-network tortuosity analysis based on the CT images revealed that more tortuous liquid-phase network formed in the quasi-saturated condition as compared to the one under water-saturated condition. As a result of column experiments, the colloid transport was facilitated in the presence of entrapped air compared to the fully -saturated condition. It was suggested that the presence of entrapped air would inhibit the deposition of silica particles at the favorable site on the sand particles.

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