Assessment of the preferential flow characteristic and flow types on a slope in a small headwater catchment

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Abstract

Preferential flow plays an important role in soil water retention, movement, and solute transport. Heterogeneity, uncertainty, and the scale of preferential flow are the focus of current research. The multi-index method and preferential flow classification method were used to identify and quantify preferential characteristic and flow types at three points of a slope in the upstream of the drinking water supply area. Results show that the infiltration depth of the preferential flow on the hillside is about 400mm. The preferential flow fraction of the staining profile ranges from 56.6 to 74.8%. The result of multi-index evaluation shows that the weight of the peak value of the staining area and coefficient of variation are the two indexes that have a greater influence on the preferential flow. Regarding the difference of preferential flow at different slope positions, the peak value of the staining area at mid-slope is higher and the coefficient of variation is lower, indicating that the preferential flow at mid-slope is more developed than at upslope and downslope. The results of the quantitative analysis of preferential flow types show that the dyeing depth can be divided into three parts with two dividing points at 100 and 275 mm due to the distribution of stain width. The main type is macropore flow, especially macropore flow with mixed interaction, accounting for 49.8, 52.2, and 61.3% at upslope, mid-slope and downslope locations, respectively. The interaction between macropores gradually decreases with increasing soil depth and increasing elevation. As for the factors influencing preferential flow type, correlation analysis found that the higher the soil moisture content, the stronger the interaction between macropores. Influenced by bulk density, saturated conductivity, and porosity, matrix flow in the soil is relatively stable with a depth of approximately 10 cm. The results can provide a reference for the subsequent research on the preferential infiltration mechanism on different slope positions and the transport characteristics of water and nutrients.

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