Assessment of the preferential flow characteristics 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 the current research. The multi-index method and preferential flow classification method were used to identify and quantify preferential characteristics and flow types at three points on a slope in the upstream portion of a drinking water supply area. Results show that the infiltration depth of the preferential flow on the hillslope is about 400 mm. The preferential flow fraction of the stain profile ranges from 56.6 to 74.8%. The result of multi-index evaluation indicates that the weight of the peak value of the stained area and coefficient of variation are the two indexes that have a greater influence on the preferential flow. Regarding the difference in preferential flow at different slope positions, the peak value of the stained 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 upslope and downslope. The results of the quantitative analysis of preferential flow types indicate that the dyeing depth can be divided into three parts with dividing points at 100 and 275 mm due to the distribution of the stain width. The main flow type is macropore flow, especially macropore flow with mixed interaction, accounting for 49.8, 52.2, and 61.3% of the flow types 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 study results can provide a reference for subsequent research on the preferential infiltration mechanism at different slope positions and the transport characteristics of water and nutrients.

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