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Information entropy to measure the spatial and temporal complexity of solute transport in heterogeneous porous media

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The complexity of the spatial structure of porous media, randomness of groundwater recharge and discharge (rainfall, runoff, etc.) has led to groundwater movement complexity, physical and chemical interaction between groundwater and porous media cause solute transport in the medium more complicated. An appropriate method to describe the complexity of features is essential when study on solute transport and conversion in porous media. Information entropy could measure uncertainty and disorder, therefore we attempted to investigate complexity, explore the contact between the information entropy and complexity of solute transport in heterogeneous porous media using information entropy theory. Based on Markov theory, two-dimensional stochastic field of hydraulic conductivity (K) was generated by transition probability. Flow and solute transport model were established under four conditions (instantaneous point source, continuous point source, instantaneous line source and continuous line source). The spatial and temporal complexity of solute transport process was characterized and evaluated using spatial moment and information entropy. Results indicated that the entropy increased as the increase of complexity of solute transport process. For the point source, the one-dimensional entropy of solute concentration increased at first and then decreased along X and Y directions. As time increased, entropy peak value basically unchanged, peak position migrated along the flow direction (X direction) and approximately coincided with the centroid position. With the increase of time, spatial variability and complexity of solute concentration increase, which result in the increases of the second-order spatial moment and the two-dimensional entropy. Information entropy of line source was higher than point source. Solute entropy obtained from continuous input was higher than instantaneous input. Due to the increase of average length of lithoface, media continuity increased, flow and solute transport complexity weakened, and the corresponding information entropy also decreased. Longitudinal macro dispersivity declined slightly at early time then rose. Solute spatial and temporal distribution had significant impacts on the information entropy. Information entropy could reflect the change of solute distribution. Information entropy appears a tool to characterize the spatial and temporal complexity of solute migration and provides a reference for future research.