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How to predict hydraulic conductivity of unsaturated soils from an incomplete soil water characteristic curve?

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Unsaturated soils are those in which pore is filled partially with water and partially with air. They are the most relevant porous medium to human activities, and cover almost all the soils near the ground surface. Hydraulic conductivity (HC) is one of the most important and useful properties of unsaturated soils in numerous studies, including governing flow process, settlement of soil foundations, migration of groundwater and gas hydrate. Unfortunately, direct measurement of HC for unsaturated soils is very difficult with high uncertainty due to its nature of complexity and limited experimental conditions. Thus, indirect estimation of HC from soil water characteristic curve (SWCC) becomes an alternative way and being widely used all over the world.

Because of the difficulty to reach high suction at the residual state of unsaturated soils, however, the SWCC obtained by laboratory experiments is often incomplete, which will lead to an unreliable estimation of hydraulic conductivity. However, no study has been published on how to estimate hydraulic conductivity of unsaturated soils with incomplete SWCC. In response to this situation, an innovative method was proposed based on the classical van Genuchten model and Mualem model. The proposed method was evaluated by extensive experimental data from existing literature and proved to have an excellent performance in predicting a complete SWCC for a wide range of soils. Also, it exhibits certain superiority in predicting hydraulic conductivity. The limitations of the proposed method were comprehensively discussed, and its corresponding improvement strategies were also addressed. This paper presents a practical way to obtain a more reliable hydraulic conductivity from incomplete SWCC.