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Assessing the accuracy of hydraulic conductivity estimation methods in heterogeneous soil environments with emphasis on grain size

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Hydraulic conductivity, a fundamental property in groundwater hydrology, plays a pivotal role in understanding subsurface flow dynamics and environmental assessments. Accurate estimation of hydraulic conductivity is essential for groundwater resource management, environmental impact assessments, and geotechnical engineering. This study delves into the assessment of different hydraulic conductivity estimation methods across diverse soil types and locations, with a specific emphasis on the influence of grain size. The research spans multiple study locations, each characterized by distinct soil types, ranging from coarse sands to fine gravels. Expected hydraulic conductivity ranges were established for each soil type, providing a critical benchmark for accuracy assessment. The study incorporates 16 widely used estimation methods, including Hazen, Hazen K ($\text{cm/s} = d_{10} \text{ (mm)}$), Slichter, Terzaghi, Beyer, Sauerbrei, Kruger, Kozeny-Carmen, Zunker, Zamarin, USBR, Barr, and Alyamani and Sen, Chapuis, Krumbein and Monk, and Shepherd. These methods were selected based on their prevalence in groundwater modeling and geotechnical engineering. Findings from this research reveal significant variability in hydraulic conductivity estimations among