Variability of hydraulic conductivity in the hyporheic zone

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ABSTRACT
The aim of this research was to investigate the variability of hydraulic conductivity in the hyporheic zone and its impact on the diurnal fluctuations of the water level. Four experimental series were performed in laboratory conditions using seepage columns, similar in size to the original Darcy columns. Four types of sand sediments, with a hydraulic conductivity ranging from $6 \cdot 10^{-6}$ to $5 \cdot 10^{-4}$ m/s, were tested. Experiments were performed at room temperature and in a cold room – at 10°C, which is similar to the temperature of the hyporheic zone.
The obtained values of hydraulic conductivity depended on the sand size, temperature of water and sand, the direction of the hydraulic gradient, and the fluidization of the sediment (liquefaction of the sand). For all tested sands, higher hydraulic conductivity values were obtained for experiments conducted when water was set to flow in the opposite direction to gravity (water was seeping out of the sediment) relative to experiments with water flow in the same direction as gravity (water seeping into the sediment). Before fluidization, with an increase of the hydraulic gradient, values of hydraulic conductivity were two times higher in experiments when water seeped out of the sediment, relative to experiments performed for water flowing in the opposite direction. After fluidization, when analyzing a decrease in the hydraulic gradient, the obtained values of hydraulic conductivity were roughly 12 times higher.
The initiation of the fluidization process in the tested columns has been observed at a hydraulic gradient close to unity. This observation has been confirmed by a mathematical model of sediment fluidization, which is based on the momentum balance and the effective stress law for a homogeneous porous material saturated with a liquid that flows at a constant velocity. Mathematical predictions of critical hydraulic gradient values and flow velocities at which fluidization is initiated have been confirmed by the column experiments.