
Using distributed Brillouin optical fiber temperature sensor to determine the groundwater velocities in an alluvial aquifer – Case of the Port-Douvot experimental site (Besançon, France).

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Résumé

Geological formations such as alluvial sediments are known to be highly heterogeneous in terms of grain size distribution which has direct consequences on groundwater velocities. Alluvial aquifers are widely exploited worldwide for their productivity, the current climatic and socio-economic changes are urging us to adopt innovative methods to better understand these hydrosystems. The experimental site of Port-Douvot is used to demonstrate the potential of Brillouin distributed fiber sensor for the measurement of groundwater velocities. The flow measurement is obtained by using an active heating method based on heatpulse instrument. An industrial sensor cable with single mode and multimode fiber was inserted vertically in the alluvial formations of the experimental site. We compare distributed Brillouin sensor reflectometry (BOTDR) and Analysis (BOTDA) on single mode fiber (SMF) and multimode optical fiber (MMF) with a spatial resolution of 1 m, a temperature resolution of 0.2 °C and an acquisition time of 1 min. The BOTDA configuration on single-mode fiber shows the best sensibility of 0.21°C because the fiber is connected at both ends and the signal-to-noise ratio is better than compared to the BOTDR method. These parameters are compatible with hydrogeology applications. Active heating of borehole water in conjunction with fiber optic distributed temperature sensor measurements is realized. Contrary to Raman-based distributed temperature sensors, the Brillouin instrument allows us to measure the absolute temperature and simplify the experimental setup. The measured velocities are of the order of 10⁻⁷ m/s which is coherent with the porous medium with alluvial sediments. The use of distributed temperatures with the Brillouin instrument could be an additional tool for groundwater management in both the quantitative and qualitative aspects.

Mots-Clés: Alluvial aquifer, Groundwater velocity, Brillouin, Water management

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