[EE] Evening Poster | A (Atmospheric and Hydrospheric Sciences) | A-GE Geological & Soil Environment

[A-GE31]Subsurface Mass Transport, Material Cycle, and Environmental Assessment

convener:Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo), Hirotaka Saito(東京農工大学大学院農学研究院, 共同), Yasushi Mori(Graduate School of Environmental and Life Science, Okayama University)
Mon. May 21, 2018 5:15 PM - 6:30 PM Poster Hall (International Exhibition Hall7, Makuhari Messe)
This session covers the topics on mass transport, water and energy cycles in geoenvironment. Subjects related to laboratory and field measurements, theoretical analysis, and numerical modeling will be discussed. Presentations on geo-pollution, remediation, geological disposal of hazardous wastes, ground source heat utilization, mass transport in vadose zone, soil-water monitoring, and environmental assessment are encouraged.

[AGE31-P06]Simultaneous measurement of soil matric potential and water content with dual probe heat pulse

*Tomoyuki Kawashima[1], Yuki Kojima[2], Kosuke Noborio[3], Koji Kamiya[2] (1.Graduate School of Natural Science and Technology, Gifu University, 2.Faculty of Engineering, Gifu University, 3.School of Agriculture, Meiji University)

Keywords:matric potential, soil water content, dual probe heat pulse, thermal conductivity, volumetric heat capacity, porous media

Soil matric potential (Ψ$_m$) and soil volumetric water content (θ) are important hydraulic properties which control liquid water transfer in vadose zone. Those properties also can be utilized for evaluating slope stability and for managing irrigation. There are several methods to measure Ψ$_m$ and θ, e.g., tensiometer, time domain reflectometry, and capacitance sensor. Those sensors have been commercialized and widely used. However, there are no commercialized sensor which can measure both Ψ$_m$ and θ simultaneously, and, thus, they have been measured independently by installing multiple sensors at the same location. In that case, there are several problems that sensors interact one another, each sensor has different sampling volume, and moreover, purchasing multiple sensors requires a large cost. Therefore, the objective of this study is to develop a sensor that can measure Ψ$_m$ and θ simultaneously, and to evaluate its performance.

We developed a sensor measuring Ψ$_m$ and θ simultaneously by improving the sensor design of a Ψ$_m$ sensor made of porous media in conjunction with dual probe heat pulse (DPHP) technique developed by Kojima et al. (2017). DPHP is a method to simultaneously measure volumetric heat capacity (*C*) and thermal conductivity (λ) of soil. Kojima et al. (2017) applied DPHP to a porous medium made of Kaolinite and equilibrated with surrounded soil. They measured *C* and λ of the porous medium and converted them into Ψ$_m$ by the preliminary obtained relationship. We extended the DPHP probe in the porous medium from 40 mm to 80 mm, and made them projecting into soil. By this change, the sensor can measure thermal property in two places, i.e., in porous media and in soil. Ψ$_m$ is estimated from the thermal properties of porous media, and θ is estimated from *C* of soil.

An experiment to obtain relationships between thermal properties of porous media and Ψ$_m$, and to evaluate the accuracy of θ estimation by the developed sensor (hereafter, DPHP Ψ$_m$-θ sensor). A cylindrical container (46 cm diameter and 9 cm height) was filled with soil (Andisol) with a bulk density of 0.84 Mg cm^{-3}. Five DPHP Ψ$_{m}$-θ sensors, two 5TEs (METER Group, Inc.) which measure θ, two MPS-6s (METER Group, Inc.) which measure Ψ$_{m}$, and one tensiometer were inserted at 4.5 cm depth. The soil in the container was left in a constant temperature room (20°C) after it was saturated by tap water. The soil was naturally dried by evaporation for 30 days. The relationship between thermal properties of porous media measured with DPHP Ψ$_{m}$-θ sensor and Ψ$_{m}$ measured with tensiometer and MPS-6 was evaluated. And the accuracy of θ estimation with DPHP Ψ$_{m}$-θ sensor was evaluated by comparing the estimated θ to that measured with 5TE.

The relationships between Ψ$_{m}$ and *C* or λ of porous media could be expressed by a modified water characteristics curve model. Accuracies of Ψ$_{m}$ estimation from *C* were 13%-18%, and those from λ were 13-15%. Thus, Ψ$_{m}$ estimation from λ is more accurate than that from *C*. In addition, the measurable range of Ψ$_{m}$ with λ was wider than that with *C*. While using λ to estimate Ψ$_{m}$ had advantages in sensor performance, using *C* to estimate Ψ$_{m}$ was more practical because the relationship between Ψ$_{m}$ and *C* did not show significant inter-individual differences and temperature dependence. Each thermal property has advantages so that we can use both properties to accurately determine Ψ$_{m}$. The accuracy of θ estimation with DPHP Ψ$_{m}$-θ sensor was 6% which is sufficiently high.

In this study, a DPHP based sensor measuring Ψ$_{m}$ and θ simultaneously was developed. The developed sensor could estimate Ψ$_{m}$ and θ accurately, thus, it can be a powerful tool for variety of studies in vadose zone.

Citation: Kojima, Y., K. Noborio, M. Mizoguchi, and Y. Kawahara. 2017. Matric potential sensor using dual probe heat pulse technique. Agricultural Information Research. 26(4):77-85