Rapid and Fully Automated Measurement of Water Vapor Sorption Isotherms: New Opportunities for Vadose Zone Research

Our ability as soil scientists to accurately measure and model retention of water in soils at low water potentials is crucial to enhance our understanding of numerous important environmental processes. At very low potentials (dry conditions), water retained in or lost from soils is in vapor form and hence the term “water vapor sorption isotherm” is often used to describe the relationship between soil water content and water potential.

The remediation of sites contaminated with oil, gasoline, or chlorinated compounds to reduce the risk of environmental degradation, the establishment and maintenance of nuclear waste storage facilities, and the design of landfill covers for solid waste management are all examples of application areas, where knowledge about water vapor sorption isotherms (WSI) is needed. Furthermore, because the prior wetting or drying history of a soil determines its water sorption characteristics and deviations between vapor adsorption and desorption (hysteresis), it is important to account for this phenomenon in numerical models for unsaturated water flow in soils. Additionally, several soil properties such as clay content, cation exchange capacity, specific surface area, and water repellency, which are important for numerous soil biological, chemical, and hydrological processes, may be derived from accurately measured WSIs.

The current challenge is to overcome our limited ability to measure detailed and accurate WSIs within a reasonable time period and to develop mechanistic or empirical relationships between measured WSIs and the processes and properties described above. Until recently, commonly applied technologies for measuring WSIs for soils included manual, single-point instruments based on the chilled-mirror dewpoint theory, which requires weeks for sample equilibration. Considering time and costs associated with traditional measurement methods, it would be of immense benefit if WSIs could be measured within a reasonable timeframe (e.g., days) and basic soil properties be derived from these measurements.

In a study published in the January 2014 issue of the *Vadose Zone Journal*, researchers illustrated vadose zone related applications of WSIs using a new, fully automated, and rapid Vapor Sorption Analyzer. Emmanuel Arthur (Aarhus University, Denmark), in collaboration with Markus Tuller (The University of Arizona, USA), Per Moldrup (Aalborg University, Denmark), and Lis Wollesen de Jonge (Aarhus University) measured WSIs for soils from three countries (Denmark, USA, and Sri Lanka) and explored potential relationships between measured WSIs and soil properties, including clay content, cation exchange capacity, specific surface area, and water repellency.

Experimental results revealed that detailed and accurate WSIs accounting for both adsorption and desorption could be obtained within one to three days for all investigated soils. The ratio of the amount of water remaining in the soil during drying to that retained during wetting was proposed as an index of hysteresis, which could be included in existing numerical models. Furthermore, analyzing previously published data on volatilization of volatile organic compounds (VOCs) and the measured WSI for the same soil, an example for the relationship between VOC volatilization and relative humidity was derived. This can aid researchers in identifying the relative humidity at which volatilization is a minimum and can assist in predicting the transport and fate of volatile contaminants.

The measured WSIs were used to estimate clay content and approximated soil-specific surface area with a high degree of accuracy.