Direct and Quick Monitoring of Water Potential in Dry Soil

Root water uptake and soil water flow, which carry heat and various substances, are caused by the difference in water potential between the involved media. Microbial activity in soils and powder also depends on the water potential. It is fundamentally important to evaluate water potential in dry media for research on wilting and plant growth, water and nutrient management in arid areas, soil salinization during evaporation, and grain storage. Furthermore, estimating water potential in relatively dry soil is required in the development of accurate soil hydraulic conductivity models.

When soil is exposed to subzero temperatures, most of the water in the soil pores freezes, but some remains unfrozen. A decrease in unfrozen water with temperature produces a dry-like environment, resulting in lower soil water potential in frozen soil. Therefore, measuring water potential in relatively dry (frozen) soil is also important to design effective use of cold regions and to investigate energy and heat balances in the cryosphere, which play key roles in global climate change.

If sampling is available, almost all ranges of soil water potential can be measured by combined use of the falling-head and pressure plate methods and equilibration over a salt solution. However, a "small" sensor is required to monitor the ever-changing water potential at particular observation points. Recent progress in sensor technology is remarkable, as the measurement range of tensiometers has been extended to about –200 kPa. Sensors that measure the dielectric constant or heat dissipation of a porous matrix in equilibrium with surrounding soil are available, and they can estimate water potential from –10 to –2500 kPa, but their accuracy and response times need to be improved.

Water potential in dry soil can also be estimated from the relative humidity of water vapor in equilibrium with soil water. Technology based on dew point measurement using a chilled mirror is exceptional from the viewpoint of accuracy and response time. However, current chilled-mirror potential meters require a sampling chamber and, thus, cannot directly monitor temporal changes in water potential in soil with water flow.

Azbil Corporation (Tokyo, Japan) developed a finger-sized chilled-mirror hygrometer, called the FINEDEW, which is small, does not require a sampling chamber, and can be placed directly in porous media. In the November–December 2012 issue of the *Soil Science Society of America Journal*, researchers used FINEDEW to monitor soil water potential under various conditions. FINEDEW quickly and accurately measured soil water potentials at < –500 kPa in soil under near-equilibrium conditions, < –1000 kPa with water flow during evaporation, and < –0.5°C under freeze/thaw conditions, with no disturbance of moisture or the thermal environment. The findings suggest that soil water potential in frozen soil requires time to reach equilibrium after a temperature change and induces non-equilibrium water flow during soil freezing.

FINEDEW is a powerful and prospective sensor, but further studies are needed of its use in long-term monitoring under field conditions. Additionally, a combination of other sensors is still required to measure all soil water potential ranges. This future application would make it possible to clarify water potential in environments in which it has never been measured and improve numerical models and water management in various fields.

Adapted from Watanabe, K., M. Takeuchi, Y. Osada, and K. Ibata. 2012. Micro-chilled-mirror hygrometer for measuring water potential in relatively dry and partially frozen soils. Soil Sci. Soc. Am. J. 76:1938–1945. View the full article online at https://dl.sciencesocieties.org/publications/sssaj/abstracts/76/6/1938

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