Journal of Hydrology (NZ) 34(2): 129-131, 1995

Review: The IH capacitance probe for measurement of soil water content

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Institute of Hydrology (U.K.), Report No. 125, 1994.

The measurement of soil moisture is now an enormously important and popular activity among environmental scientists, engineers and managers. Some ten years ago the world of soil moisture measurement seemed to have stabilized, and the neutron probe was 'king' among the field methods. However the last decade has seen rapid progress in the development and commercial provision of new methods. Leading amongst these are the electromagnetic (e.m.) methods, which measure volumetric water content via the strong dielectric effect of liquid water, and fall into two categories.

I Travelling wave methods, commonly termed Time Domain Reflectometry (TDR). These rely on measurement of the transit or 'echo' time (c. nanoseconds) of an e.m. wave propagating in the medium: the greater the water content, the slower the wave travels. TDR technology has now progressed to enable measurement of the water content profile from segmented waveguides pushed or buried in the soil.

II Capacitance methods. Here, the soil forms a dielectric medium surrounding the electrodes (e.g. a pair of steel rods) which define a capacitor. Increased water content raises the bulk dielectric coefficient of the soil, which raises the capacitance and hence alters the frequency of an oscillator circuit containing the capacitance.

The IH probes (Fig. 1) described in this publication are of the capacitance type. While developed at the Institute of Hydrology, the probes are manufactured by the Didcot Instrument Co., U.K. Three probe types are described.

1. *Access tube version* (Fig. 1a). A main incentive for developing this was the failure of the neutron probe to measure accurately in the surface 15 to 20 cm. The sensor (Fig. 1a) is lowered into a pre-installed PVC access tube (diameter c. 5 cm), and the reader unit displays the oscillator frequency, which is then (after suitable calibration) converted to volumetric water

content. A disadvantage of the probe is its small 'volume of influence': the e.m. field determining instrument response has an approximate radius of 6.5 cm, and thus extends radially only c. 4 cm outside the access tube. By contrast, the 'sphere of influence' of a neutron probe has radius between 10 and 25 cm (wet and dry soil respectively). Hence, careful access tube installation is much more critical than for the neutron probe.

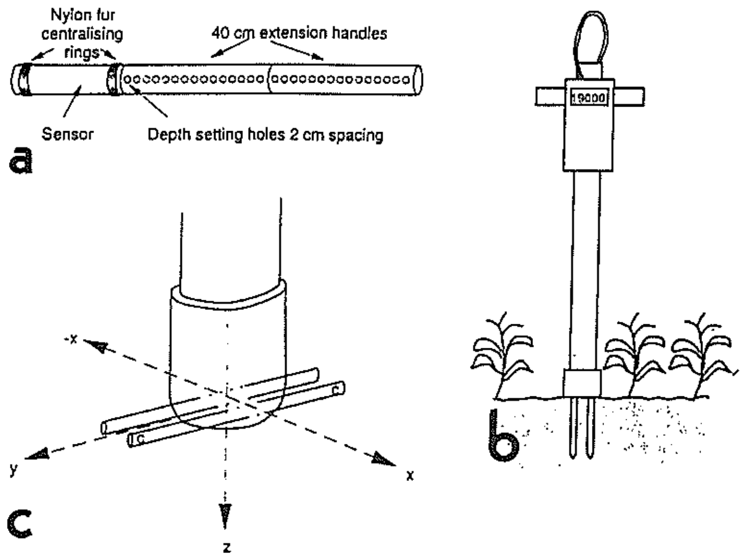

FIG 1

2. *Surface probe* (Fig. 1b). The probe rods are 100 mm long and so with direct insertion give water content of the top 10 cm. With the use of spacer blocks slid over the upper part of the rods, insertion depths of 5, 2 or even 1 cm are possible. Assuming that reliable, repeatable readings can be obtained, this offers the exciting prospect of measurement of thin surface layers, useful in e.g. studies of surface energy balance, evaporation, germination, or in ground-truth for remote sensing. There is a desperate need for such thin-layer techniques.
   The instrument, still in prototype form, has strong sensitivity to the presence of materials in the fringes of its electric field, so that hands and body must be kept clear of the lower part of the instrument during measurement.

3. *Masonry probe* (Fig. 1c). This non-invasive modification is designed to measure surface water content in masonry blocks, or on drying-hardened soil surfaces. Again, there is a real need for such a technique in soil and hydrological science.

A further development has been the testing of a buried probe, based on the surface probe version above. This leads to the prospect of a commercial Automatic Soil Water Station (ASWS), measuring soil water content, water suction and temperature at three or more depths. Along with an automatic weather station, the ASWS concept could prove very useful in hydrological studies or flood warning systems.

The report even mentions development of a tractor-based version of the probe, for measurement from a moving tractor! A minor disadvantage of all probe versions is that instrument read-out is a frequency, rather than direct volumetric water content. However a chapter is devoted to calibration techniques and data, and "future possibilities" include incorporation of a microprocessor to convert frequency to direct readout of water content.

An interesting aspect concerns the influence of electrolytes or salts in soil. While soil salinity will interfere with results from capacitance-type probes, the capacitance technique does not enable ancillary measurement of soil electrical conductivity. This is in contrast to travelling wave (TDR) methods, which enable simultaneous measurement of water content and bulk electrical conductivity (from the speed and attenuation of the wave, respectively).

The report is well and clearly written, with the exception that the depth resolution (and hence near-surface response) of the access-tube version is not discussed.

The overall impression is of a promising suite of probes based on the capacitance method. Particularly exciting are the prospects of (a) surface probes enabling thin-layer measurements, and (b) commercial availability of an 'Automatic Soil Weather Station'.

Graeme D. Buchan
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CORRIGENDUM

Volume 33, No. 2

On page 125 of Kelliher et al., the parameter θ in equation (1) was incorrectly printed two times as q in the text. In Table 1 on page 126, the river discharge rate on 14 August 1965 was 1905 m^3s^{-1} and not 905 m^3s^{-1} as printed.