SOIL MOISTURE MEASUREMENTS WITH AN IMPROVED TIME DOMAIN REFLECTOMETRY SYSTEM (TRIME)

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INTRODUCTION

Water content measurements are the crux of all hydrological studies. Standard methods such as oven drying, neutron moderation, or gamma reduction, involve a lot of disadvantages, such as being time-consuming, destruction of test sites, and use of hazardous radioactive sources. The relatively new Time Domain Reflectometry (TDR) technique (Topp et al. 1980) avoids these disadvantages and is gaining more and more acceptance.

METHOD

The determination of volumetric water content is based on the reflection of a high-frequency electromagnetic pulse on metallic rods embedded in the soil, with which the dielectric constant, mainly a function of water content in moist soil, can be determined and a suitable calibration function then yields the water content. But conventional TDR systems developed for electrical engineering to detect cable damages and adopted by soil scientists for water content determination are not very convenient for field application. The expensive, complex, and heavy hardware; high power consumption; and need for graphical waveform interpretation pose several problems.

We have developed a new TDR technique (Stacheder et al. 1994), the "TRIME method", which avoids the need for a high-frequency (HF) pulse generator, a sampling oscilloscope or a cable tester. The use of sophisticated application-specific analog and digital integrated circuits (ASIC), new

waveform-processing hardware, and algorithm allow the production of devices with small dimensions and the construction of probes that are independent of HF-cable length. The measuring time and power consumption are considerably reduced. The new probes can be interlinked by a digital two-wire bus and located along a serial data network up to 3km in length. The measurement values can be logged by a PC or the probes can be connected to a datalogger. For the first time, the use of small rod-probes (0.05 m) to measure water content (<5%) by volume and the construction of a TDR tube probe that allows the measurement of a water content profile in the soil via a glass fiber access tube are possible.

RESULTS

The new technique was tested with several soils ranging from fine sand to heavy clay (Table 1) and a universal relationship was established. The reference method was the oven-drying technique (at 105°C). The mean absolute accuracy for water content determination was about ±1.5% by volume, and the new system had a repeatability of ±0.5% by volume.

The possibility of determining soil bulk electrical conductivity with the new system has also been investigated, which makes TDR an interesting new tool in subsurface solute transport investigations.

REFERENCES

Stacheder, M.; Fundinger, R.; and Koehler, K., 1994. 'A New Time Domain Reflectometry System (TRIME) to Measure Soil Moisture and Electrical Conductivity'. In *U.S. Bureau of Mines Spec. Publ.*, SP 19-94 (pp56-65).

Topp, G.C.; Davis, J.L.; Annan, A.P., 1980. 'Electromagnetic Determination of Soil Water Content: Measurements in Coaxial Transmission Llines'. In *Wat. Resour. Res.*, 16 (pp574-582).

Table 1 Characteristics of Materials Used for Soil Water Content Determinations

Material	Organic material (%)	Texture (%) Clay (< 0.002mm)	Silt (0.002-0.05mm)	Sand (0.05-2mm)	Bulk density range, g/cm^3
Fine sand	-	-	2	98	1.4-1.6
Glass beads	-	-	-	100	1.6
Bentonite	4.7	68	27	5	0.5-1.3
Rendoll	12.8	6	66	28	0.7-1.2
Loess loam	4.9	19	61	20	1.0-1.5
Kaolin	3.4*	38	60	2	1.0-1.4

* Loss on ignition determined at 400°C