AGENG

WARWICK 2000

EurAgEng

Paper Number: 00-SW-018

Title:

The use of Wenner configuration to monitor soil water content

Authors:

Agodzo, S. K.(*); Okyere, P. Y.; Kusi-Appiah, K.

School of Engineering, Kwame Nkrumah University of Science and Technology, Kumasi (KNUST), Ghana. Tel: +233 (0)51 60328/60242 Fax: +233 (0)51 60137 email agodzo@avuust.africaonline.com.gh

Summary:

A field investigation of the relationship between soil resistivity (R_s) and soil water content (*WC*) was conducted using the 4-probe Wenner Configuration Method (WCM). The WMC is traditionally used by electrical engineers for earth testing but was adapted for use as a soil water monitor in this study. Calibration curves were established between R_s and *WC*, demonstrating that the earth tester can be used for such measurements. Power correlation ($R_s = k\ WC^n$) with r^2 values of 0.81, 0.83 and 0.97 were obtained for electrode spacing of 1400, 1300 and 1200 cm respectively. Linear correlation ($R_s = c\ WC + d$) yielded r^2 values 0.68, 0.87 and 0.99 for 1400, 1300 and 1200 cm respectively. Generally, both the linear and power relationships get weaker with increasing spacing between electrodes. However, the power relationship holds better at higher electrode spacing while the linear relationship holds better at lower electrode spacing. The bulky nature of the equipment rendered the measurements cumbersome. It must be noted that electrode spacing of between 12 to 14 m will affect the spatial variability of the soil. This must have accounted for the weaker correlation as the electrode spacing increased, considering that the theory on which the earth tester is based assumes a homogeneous soil.

Introduction and Purpose

Engineers, agronomists and other professionals, at a stage in their professional work, need to know the amount of water in the soil and to be able to measure it quite accurately, easily and quickly. Water content determination of the soil is usually accomplished by direct and indirect methods. The purpose of this work is to adapt a method, traditionally used by electrical engineers for earthing landed properties against thunder, for soil water content determination. The method is known as the Wenner configuration method (WCM).

Approach

The method is an indirect one, which measures soil water content (*WC*) as a function of soil resistivity (R_s). Four metallic probes were driven into the ground with typical orientation (Figure 1). Soil resistivity at site was determined by sending electrical current through the ground via the electrodes. Resistance (*R*) was measured by the changes in voltage between horizontal electrode distances within the electrical field created by the current via the electrodes. With a homogeneous soil, Neidle (1975) computed soil resistivity as:

$$R_s = 4\pi aR = 12.6aV/I \tag{1}$$

where R_s= soil resistivity (ohm-cm)
R = soil resistance (ohm)
V = voltage (V)
I = Current (A)
a = electrode spacing (cm) = $10b$
b = electrode depth (cm)

Soil water contents (weight basis) were determined using the oven method for corresponding resistance measurements for electrode spacing of 1200, 1300 and 1400 cm.

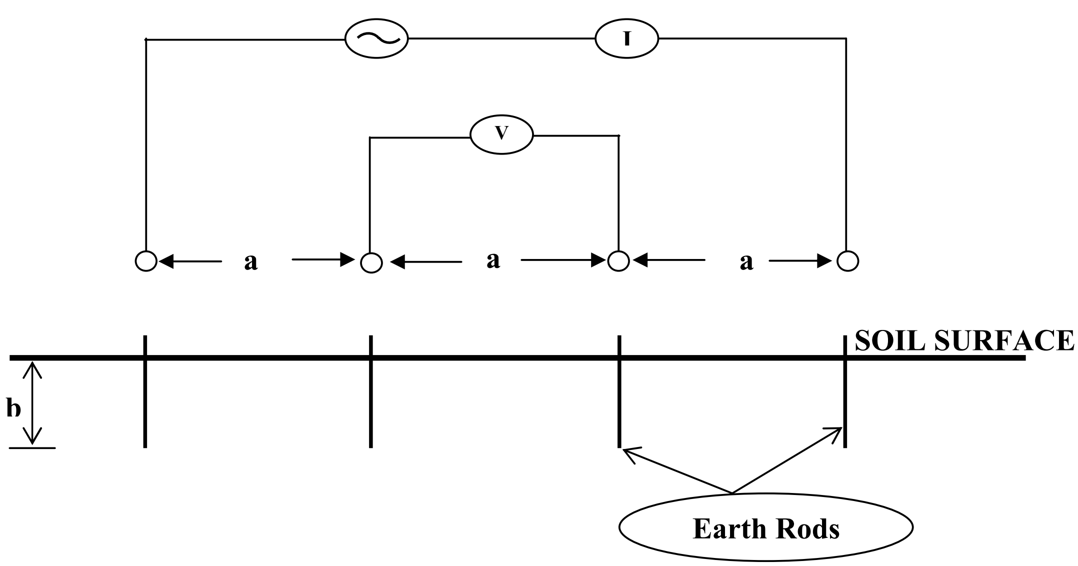

Figure 1. Experimental set-up

Results and Discussion

Calibration curves (Table 1) were established between R_s and WC, demonstrating that the earth tester can be used for such measurements. Power correlation ($R_s = k\ WC^n$) with correlation coefficient squared (r^2) values of 0.81, 0.83 and 0.97 were obtained for electrode spacing of 1400, 1300 and 1200 cm respectively. Linear correlation ($R_s = c\ WC + d$) yielded r^2 values of 0.68, 0.87 and 0.99 for 1400, 1300 and 1200 cm respectively. Generally, both the linear and power relationships get weaker with increasing spacing between electrodes. However, the power relationship holds better at higher electrode spacing while the linear relationship holds better at lower electrode spacing.

Table 1. Wenner configuration results

Electrode spacing, *a* (cm)	Power Function $R_s = k\ WC^n$			Linear Function $R_s = c\ WC + d$		
	k	n	r^2	c	d	r^2
1200	2E+09	-4.75	0.97	-388.21	8772.8	0.99
1300	15409	-0.69	0.83	-45.67	2838.4	0.87
1400	8E+07	-3.24	0.81	-258.47	8831.2	0.68

The bulky nature of the equipment rendered the measurements cumbersome. It must be noted that electrode spacing of between 12 to 14 m will affect the spatial variability of the soil. This must have accounted for the weaker correlation as the electrode spacing increased, considering that the theory on which the earth tester is based assumes a homogeneous soil. In fact this could even be an advantage with the method in that the measurement provides an integration of the effects of soil heterogeneity rather than homogeneity, which is in fact what pertains at the field level. Another advantage of the method is that a larger soil volume can be monitored to be representative of a wider area.

Conclusion

The oven method remains the standard method for the determination of soil water content but field sampling to be representative of a large area is still a problem. The other methods like tensiometry, neutron probing, gamma-ray attenuation and soil resistivity-based monitoring (Cassel and Klute, 1986) have become mainly research tools in understanding soil water behaviour but of limited practical field applicability. The Wenner configuration method, which is soil resistivity-based only adds to the existing procedures, but still with limited field applicability. The main advantage as already mentioned is that the method samples a larger soil volume and provides measurements for an integrated effect of soil heterogeneity rather than soil homogeneity at the field level. Further adaptations could be investigated to make the method more practicable.

References

Niedle, M. (1970). Electrical installation technology. Butterworths, London. pp380.

Cassel, H. and A. Klute (1986). Methods of soil analysis: physical and mineralogical methods, American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin, USA. pp1188.