Pak. J. Agri. Sci.
24 (2) 123, 1987

A RAPID METHOD OF APPRAISING SOIL SALINITY

Javed Akhter, R. A. Waheed, Z. Aslam and Kauser A. Malik.

Soil Biology Division
Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan.

This paper describes a technique for in situ-measurement of soil electrical conductivity using a four-electrode EC-probe. The study has been conducted in the field on a loam soil having a wide rang of salinity levels and a calibration curve has been prepared showing relationship between soil electrical conductivity (EC_e) and bulk soil electrical conductivity (EC_b) In addition a calibration curve showing relationship between apparent solution conductivity (EC_s) and actual EC of synthetic saline solutions has been reported. The correlation found in both the above cases are highly significant and results are reproducible.

INTRODUCTION

The electrical conductivity of saturation soil extract (FC_e) is a conventional measure of soil salinity, though the ideal method of appraising the salinity consists of measuring the salt concentration of an extract obtained at field water content (Bower & Wilox, 1966). In the later method, the difficulty of obtaining soil extract limits its routine use.

The standard laboratory technique in which soil samples are wetted to a saturated paste has some demerits (McNeal *et al.*, 1970; Oster & McNeal, 1971; Ulrich & Khanna 1972). The most important may be the effect of dilution upon the EC of the extract, a disruption of gaseous equilibria notably CO_2–carbonate system occurs which exerts a significant effect on the EC (Frear & Johnston, 1929). Moreover, the increased solubility of some ions, like bicarbonate or borate, may cause an over-estimation of their concentration in soil.

To overcome these problems, the immiscible displacement (ID) technique was developed by Mubarak & Olsen (1977). With this method soil samples are centrifuged in the presence of a suitable organic solvent which displaces the soil solution. However, this method is also lengthy. In addition, these methods are laborious as they require transportation of samples and other laboratory facilities. For in-situ determination of bulk soil electrical conductivity (EC_b) four-electrode EC-probe was introduced and extensively used in the past decade (Halvorson *et al.*, 1977; Van Hoorn, 1980; Rhoades & Corwin, 1981).

Now a variety of inexpensive and portable devices are available which can be used for directly measuring the salt concentration in the field, i.e. eliminating the need of soil sampling and laboratory analysis. The four-electrode EC-probe is suitable for repeated non-destructive measurements of changes in the concentration of salts in soil solution during irrigation and thus inferences on salt movement can be made easily. It is less time consuming (1-2 sec.)

For routine field use the four electrode EC-probe needs to be calibrated separately for each soil texture. This study was undertaken to estimate the relationship between EC_e and EC_b for a loam soil. In addition, for extending the use of EC-probe to surface waters and free waters in water-logged areas, the relationship between EC_b and EC of various saline solutions (EC_s) is also presented.

MATERIALS AND METHODS

For the calibration of four electrode EC-probe for use in local conditions, two experiments were conducted, one in the field (Experiment A) and the other in the laboratory using synthetic saline waters (Experiment B).

A. *Calibration of four electrode EC-probe in the field*

The EC-probe EIJKELKAMP Model with GEOHM2 was used for measuring EC_b in the field. For this purpose twenty plots of differnet salinity levels (1-24 dSm^{-1}), all being loam in texture, were selected at the NIAB campus. The EC_b of top 6 inches of soil of these plots was determined by measuring the resistivity of the soil with EC-probe. The EC-probe wase inserted into the soil by making a hole with a special soil auger. At the same time, temperature was also measured by inserting a thermometer in the soil. The effect of temperature was accounted for and all values were calculated for a uniform temperature 25°C using conversion factors given in the manual, provided with the instrument.

While measuring EC_b in the field, soil samples were collected from the same points. These were later used to measure the salt concentration of soil through a 1:1 suspension (USDA, 1954) method where equal weights of dried soil and distilled water were mixed, shook for one hour, centrifuged and filtered. The EC_e of the filtrate was measured using an EC meter Model No. LF 530.

B. Calibration of four electrode EC-probe for saline water

Twenty two solutions of different EC ranging from 0.086 to 40 dSm^{-1} were prepared by mixing Na_2 SO_4, $CaCl_2$, $MgCl_2$ and NaCl in the ratio of 10:5:1:4. The EC_b of these solutions was determined by EC-probe. The data so obtained with EC-probe and EC meter were statistically analysed to calculate regression coefficients and calibration curves for the use of EC-probe both in the soil and free water systems.

RESULTS AND DISCUSSION

A. Calibration of EC-probe in the field

In the field experiment, soil was loam having a saturation percentage of 41 (Table 1). Field moisture content on dry weight basis ranged from 10 to 20% and thus was close to the value of field capacity. The calibration slope and intercept values determined were 2.98 and 0.065, respectively (Fig. 1). The reproducibility and accuracy of calibration was good as indicated by r value of 0.995 at 5% level of significance. The derived regression equation $EC_e = 2.98\ EC_b + 0.065$ may be used in the range of 0.2 to 20 dS m^{-1} giving a suitable range for calibration purpose for loam type soil at a moisture level ranging from 10 to 20 % on weight basis. The calibration of EC-probe so determined was again varified in the field on the same soil at a different time. The results obtained were identical to the earlier ones as shown by the distribution of points very close to the curve (Fig. 1).

The values of EC_b were always lower than those corresponding value of EC_e. This discrepancy was likely due to the variation in water content (Nadler 1981). A high degree of relationship between EC_e and EC_b suggested the use of simple calibrations for the same soil type for appraisal of salinity under our conditions. To extend the use of the calibration curve reported in this paper to arbitrary water content in the field, the effect of variation in water content in soil could be accounted for (Rhoades *et al*, 1976).

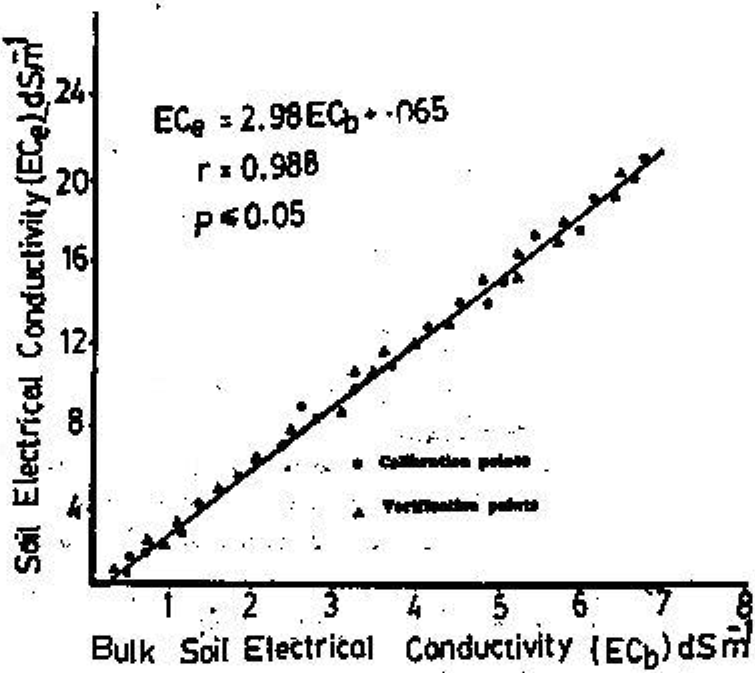

Fig.1. Relation between soil electrical conductivity (EC_e) as measured with unit LF-530 and four electrode probe.

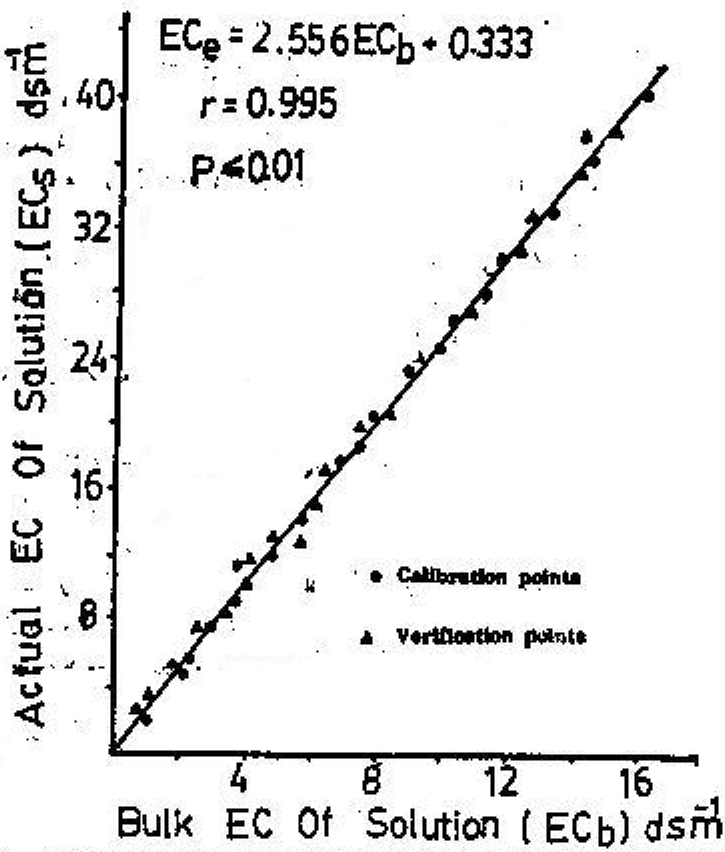

Fig.2. Relation between solution electrical conductivity (EC_s) as measued with unit LF-350 and four electrode probe.

Table 1. *Characteristics of soils under study*

EC_e, dSm^{-1}	1 to 24
pH	8.1 ± 0.4
Clay, %	13.5 ± 3.1
Silt, %	28.5 ± 1.5
Sand, %	58.1 ± 1.4
Textural class	Laom
Saturation percentage	41.35 ± 3.1
Field moisture status, % dry weight	10--20

B. *Calibration of EC-probe for saline waters*

The relationship between EC_e and EC_b has been shown in Figure 2. The values of slope and intercept were 2.556 and 0.332, respectively. The reproducibility and accuracy of calibration are good as indicated by r value of 0.955 at 1 % level of significance. This calibration curve was verified for more than 20 solutions of different EC levels after three months interval and verificaiion points were also plotted in Fig. 1 & 2 indicating stability of calibration with time. These results suggested the use of four-electrode EC-probe in the free water system, e.g. for surface waters or in the waterlogged soils. Our laboratory and field experiments suggested the use of EC-probe due to its efficiency, accuracy and simplicity for the appraisal of soil salinity under field conditions.

REFERENCES

Bower, C. A. and L. V. Wilcox. 1965. Soluble salts. In C. A. Black (ed.) Methods of Soil Analysis, Part 2, Agronomy 9:933-951.

Frear, G.L, and J. Johnston. 1929. The solubility of calcium carbonate (callite) in certain aqueous solutions at 25°C. J. Am. Chem. Soc. 51 : 2082-2093.

Halvorson, J.D., J.D. Rhoades and C.A, Reule. 1977. Soil salinity.

Four electrode conductivity relationships for soils of the northern great plains. Soil Sci. Soc. Am. Proc. 41;966-971.

McNeal B.L., J.D. Oster and J.T. Hatcher. 1970. Calculation of electrical conductivity from solution composition data as an aid to in situ estimation of soil salinity. Soil Sci. 110:406-414.

Mubarak, A. and R.A. Olsen. 1977. A laboratory technique for appraising in situ salinity of soil. Soil Sci. Soc. Am. Proc. 41:1018-1020.

Nadler, A. 1981. Field application of four electrode technique for determining soil solution conductivity. Soil Sci. Soc. Am. Proc. 15:30-34.

Oster, J.D. and B.L. McNeal. 1971. Computation of soil solution composition variation with water content for desaturated soils. Soil Sci. Am. Proc. 35 ; 422-436.

Rhoades, J.D. and D.I. Corwin. 1981. Determining soil electrical conductivity depth relations using an electromagnetic soil conductivity meter. Soil Sci. Soc. Am. Proc. 36:255-260.

Rhoades, J.D., P.A.C. Raats and R.J. Prather. 1976: Effect of liquid phase electrical conductivity, water content and surface conductivity on bulk soil electrical conductivity. Soil Sci, Soc. Am. Proc. 40 : 651-655.

Ulrich, B. and P.K. Khanna. 1972. Desorption and dissolution of salts from soils as a function of soil water ratio. Soil. Sci. 114 : 250-253.

United States Salinity Laboratory Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils,Agric. USDA. Handbook No.60. Washington, D.C.

Van Hoorn, J.W. 1980. The calibration of four electrode soil conductivity probe for determining soil salinity. In. D.R. Bhumbla and J.S.P. Yadav, International Symposium on Salt-Affected Soils. Karnal, India 18-21 Feb. 1980. National Printers, New Delhi. pp. 118-156.