Reprinted from the *Soil Science Society of America Journal*
Volume 43, no. 4, July–August 1979
677 South Segoe Rd., Madison, WI 53711 USA

INEXPENSIVE FOUR-ELECTRODE PROBE FOR MONITORING SOIL SALINITY[1]

J. D. RHOADES[2]

Abstract

Description is given of the construction and use of an inexpensive four-electrode probe suitable for permanent installations and for in situ monitoring of soil salinity. Data illustrative of its use are presented.

Additional Index Words: **soil electrical conductivity, earth resistivity.**

Rhoades, J. D. 1979. Inexpensive four-electrode probe for monitoring soil salinity. Soil Sci. Soc. Am. J. 43:817–818.

THE four-electrode method of measuring soil electrical conductivity (EC_a), developed for purposes of determining field salinity (Rhoades and Ingvalson, 1971), is gaining acceptance as its utility and validity are demonstrated and as its instrumentation is improved. Theory of the measurement has been developed and verified (Rhoades et al., 1976) and a commercially available probe[3] has been developed using the four-electrode principle (Rhoades and van Schilfgaarde, 1976). Accurate and simple methods have been developed for calibrating soil salinity and soil electrical conductivity (Rhoades, 1976; Rhoades et al., 1977). Applications of the method for measuring, mapping, and monitoring field salinity and water-table depths, and detecting encroaching saline seeps have been demonstrated (Rhoades, 1976; Rhoades and Halvorson, 1977; Halvorson and Rhoades, 1974, 1976). The state-of-the-art is sufficiently advanced now to recommend the method for many routine field salinity measurements.

Though the portable commercial probe (Rhoades and van Schilfgaarde, 1976) was designed for field salinity appraisal, salinity monitoring sometimes requires that repeated measurements be made over a period of time in the same location. For such uses, implanted probes offer certain advantages, such as the labor required to make new access holes is eliminated, repeated measurements at the same spatial position in the soil can be obtained, and complications which may arise from repeated coring of access holes in the sampling area are minimized (Shea and Luthin, 1961). For these reasons, an inexpensive four-electrode unit has been developed that can be implanted and left in the soil. This burial-type probe is described in this paper.

Description of the Probe

The four-electrode unit was designed and constructed using only the components shown in Fig. 1. The probe casing is a length of PVC pipe (0.75-inch schedule 80, 4.75 inches long) in which four grooves (0.40 inches wide and 0.025 inches deep)

[1] Contribution from the U. S. Salinity Lab., USDA, Riverside, CA 92501. Received 21 Aug. 1978. Approved 28 Mar. 1979.

[2] Supervisory Soil Scientist.

[3] Martek Instruments, Inc., Irvine, Calif. The mention of a particular product or company is for the convenience of the reader and does not imply any particular endorsement, guarantee, or preferential treatment by the USDA or its agents.

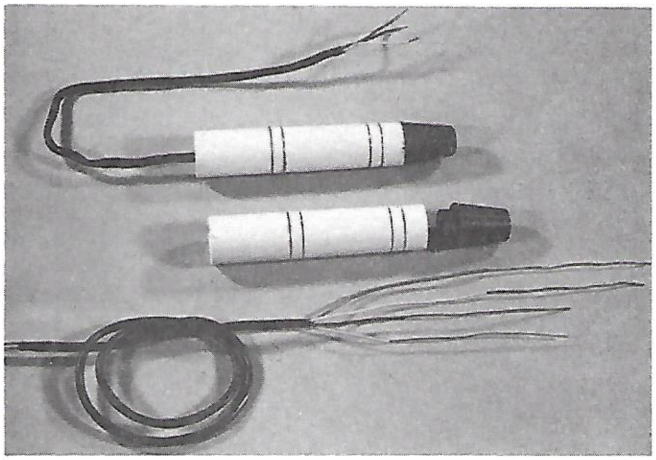

Fig. 1—Four-electrode burial probe before and after assembly.

are made. The distance between the outside grooves is 2.5 inches, the inside grooves are inset by 0.25 inches. The outside wall of the pipe is tapered at 0.5° on a lathe. Two holes (1/16 inch) are drilled in each of the grooves for the passage of 18-gauge wire (Carol Cable Co. 05684 thermostat wire)[3], with the insulation removed from the last 4 inches of wire. Each of the four bare wire ends runs from inside the pipe through a hole, is rapped around the outside of the pipe in one of the grooves to form one of the four electrodes, and is returned to the inside of the pipe through a second hole in each groove. The returned end of the wire is crimped against the pipe wall to firmly secure the wire in place. A 1.37-inch-long tapered (7° on a side) solid PVC tip is inserted into the head end of the probe and cemented with PVC solvent cement to serve as a leading edge. Finally, the inside of the pipe is filled with laminating resin to within 0.75 inch of the exit end in order to prevent water entry.

Current material costs for a single unit are about: 0.75-inch PVC pipe, $0.07; 1.0-inch PVC rod, $0.12; 3-foot length of wire, $0.18; and laminating resin, $0.25. Total $0.62.

To facilitate implanting the probe at deep soil depths, the wires are fed through a 0.5-inch pipe (electrical conduit tubing) until the end of the probe butts against the shoulder of the insertion tube (see Fig. 2). The unit can then be inserted into the soil via a 1-inch-diam access hole. I use an Oakfield soil sampling tube for this purpose. The insertion tool is then withdrawn, leaving the probe at the depth of insertion. The access hole is backfilled with soil and compacted to prevent water entry from the soil surface.

Once calibrated (the "cell constant" is determined from readings made in salt solutions of known EC) and, buried in the soil with the wires leading to the surface, soil electrical conductivity can be measured at any desired frequency, using any appropriate electrical generator/meter unit (i.e., Austin and Rhoades, 1979; Martek Instruments, Inc. Model SCT meter). Units buried in a grain sorghum field for a period of 3 mo did not significantly corrode or change in calibration during this time.

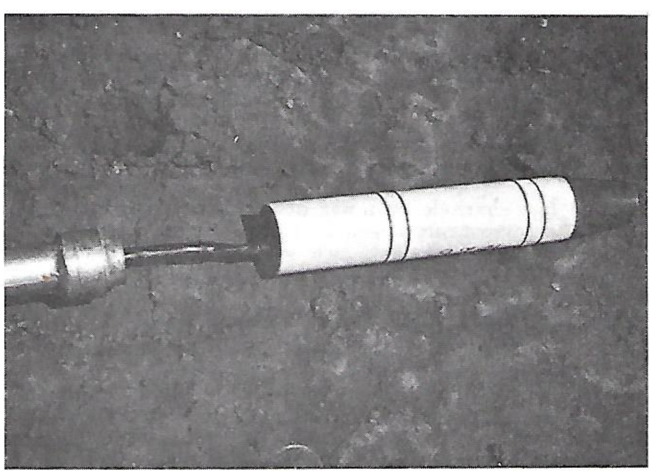

Fig. 2—Four-electrode burial probe, insertion tube tip, and access hole in soil.

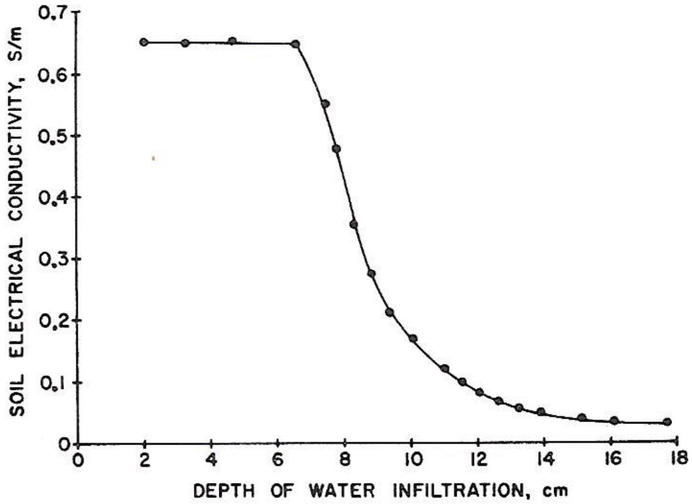

Fig. 3—Plot of soil electrical conductivity vs. depth of water infiltrated during the ponded leaching of salinized Pachappa soil.

Data illustrating the utility of the probe for monitoring purposes are given in Fig. 3. Changes of soil electrical conductivity were measured during the ponded leaching of salinized Pachappa soil (Mollic haploxeralf). In this case, the probe was buried on its side at 16.5 cm to obtain a sharper breakthrough curve. Water was ponded at a depth of 18 cm. These data show that essentially complete reclamation was achieved through the 16.5-cm soil depth with the infiltration of 14 cm of leaching water.

Literature Cited

1. Austin, R. S., and J. D. Rhoades. 1979. A compact, low cost circuit for reading four-electrode salinity sensors. Soil Sci. Soc. Am. J. 43:808–810 (this issue).
2. Halvorson, A. D., and J. D. Rhoades. 1974. Assessing soil salinity and identifying potential saline-seep areas with field soil resistance measurements. Soil Sci. Soc. Am. Proc. 38:576–581.
3. Halvorson, A. D., and J. D. Rhoades. 1976. Field mapping surface and subsurface soil conductivity to delineate dryland saline-seep areas. Soil Sci. Soc. Am. J. 40:571–575.
4. Rhoades, J. D. 1976. Measuring, mapping, and monitoring field salinity and water table depths with soil resistance measurements. FAO Soils Bull. 31:159–186.
5. Rhoades, J. D., and R. D. Ingvalson. 1971. Determining salinity in field soils with soil resistance measurements. Soil Sci. Soc. Am. Proc. 35:54–60.
6. Rhoades, J. D., and J. van Schilfgaarde. 1976. An electrical conductivity probe for determining soil salinity. Soil Sci. Soc. Am. J. 40:647–651.
7. Rhoades, J. D., M. T. Kaddah, A. D. Halvorson, and R. J. Prather. 1977. Establishing soil electrical conductivity-salinity calibrations using four-electrode cells containing undisturbed soil cores. Soil Sci. 123:137–141.
8. Rhoades, J. D., P. A. C. Raats, and R. J. Prather. 1976. Effects of liquid-phase electrical conductivity, water content, and surface conductivity on bulk soil electrical conductivity. Soil Sci. Soc. Am. J. 40:651–655.
9. Rhoades, J. D., and A. D. Halvorson. 1977. Electrical conductivity methods for detecting and delineating saline seeps and measuring salinity in North Great Plains soils. ARS W-42. 45 p.
10. Shea, P. F., and J. N. Luthin. 1961. An investigation of the use of the four-electrode probe for measuring soil salinity in situ. Soil Sci. 92:331–339.