ON THE CHARACTERISTICS OF AN ELECTRODE PROBE FOR MEASURING SOIL WATER ELECTRICAL CONDUCTIVITY

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1. INTRODUCTION:

Specific electrical conductance (EC) of the soil water is usually used in understanding the movement of soil water with dissolved solutes [1]. The measurement of EC, however, needs to get a certain amount of solution which disturbs the flow itself. To eliminate this problem, open-type electrodes are sometimes used.The value of the total electrical conductance measured by this probe is affected not only by the concentration and moisture content but also by the shape of the probe and the temperature. This paper studies property of this probe theoretically and checked by experiments.

2. EXPERIMENTAL PROCEDURES:

Laboratory investigations on the specific electrical conductance of NaCl salt solutions of varying concentrations and on the EC of NaCl solutions with glass beads (dia=0.3mm)under unsaturated conditions were carried out using electrode probes of different sizes. Each electrode probe was made up of two stainless steel cylinder pipes (dia=1.5mm O.D.) supported by plastic bars. Actual probe dimensions and the schematic shape can be seen in table 1 and in figure 1 respectively.

For the EC estimation of salt solutions, the probes were inserted in solutions and resistance values were measured.The specific electrical conductances measured by the probes, was checked by the value obtained using specific conductance meter.

For the EC estimation of the 'solution and bead' system, beads were packed in an acrylic column and the probes were placed horizontally about 0.1m below the surface of the beaded column. To determine the unsaturated condition of the soil at the probe, the suction head was measured by a porous cup connected to a pressure bulb and converted to the moisture content by a moisture content-suction head curve shown in fig.2.

3. EXPERIMENTAL RESULTS AND DISCUSSIONS:

Specific electrical conductance k (μS/cm) is a characteristic of the solution or soil-solution which relates the current flux i (A/cm^2) and voltage gradient $\partial V/\partial r$: $i = -k\partial V/\partial r$ (1)
For an electrode of two parallel cylinders (radius a , separation d) and two spheres (radius a , separation d) resultant resistance is expressed as eq. (2) and (3) respectively [2]:

$$R_C = ln\,(d/a)/\pi kl \quad (2) \ ; \quad R_S = 1/2\pi k(1/a - 1/d) \quad (3)$$

where l (cm) is the exposed length of the cylinder with a and d in cm.For finite length parallel cylinder electrodes corresponding to the probe (fig.1) we get eq. (4) by combining these two equations and introducing a contact conductance k_c (μS/cm^2) between metal and liquid.

$$\frac{1}{R} = \{ln\,(d/a)/\pi kl + 1/(\pi alk_c)\}^{-1} + \{1/(2\pi k)(1/a - 1/d) + 1/(2\pi a^2 k_c)\}^{-1} \qquad (4)$$

In figure 3, with exception to very low specific conductance values, the contact conductance is seen to be nearly a constant for each probe; however, the values vary from probe to probe. We were expecting that this contact conductance is a fixed value for all the probes. No trend is observed with the results and we are looking into the possibility that some of the probes may have been contaminated with dirt or some exposed length of wires or cylinder surface has been unaccounted for contributing to error. In figure 4, specific conductance values *in solution* by the probes are checked by comparing EC values obtained by using a specific conductance meter.The longer probes were found to respond better to the derived eq(4) as compared to the shorter probes.

Continuing the experiments to the 'bead and solution' system, shown in figure 5, we find that decreasing moisture contents brings a decrease in the specific conductance measured by the probe. The increase of EC of the solution to that of the first solution is about fifteen times, but small changes in EC is noticed for the 'bead and solution' system indicating that moisture changes affects the EC measured by the probes greatly.This is expected since the soil water is the main carrier of the ions in solution.

4. CONCLUSIONS:

The results of this study is summarized as follows:

(1) Contact conductance values in solution shows to be a constant for each probe within the range considered (SC=77 to 882 μS/cm); however, the values vary from probe to probe without any trend.
(2) The derived equation (4) for the EC of the probe is seen to be effective for longer sized probes.

5. REFERENCES:

[1] Matsubayashi,U.,G.T.Velasquez,F.Takagi, (1991) Separation of New and Old Waters using Specific Conductance..., *Proceedings on Hydraulic Engineering ,JSCE* , V.35,99-104 pp.99-104.

[2]Kasper,C.,(1940): The Theory of the Potential and the Technical Practice of Electrodeposition, Part 2,*Trans. Electrochemical Society* ,V78, pp.365-385.

Actual Lengths (cm)	Length		
Separation Distance	L=2cm	L=4cm	L=5cm
5mm	2.05	4	5
7mm	2	4	5.03
10mm	1.98	4	4.96
Actual Separations (mm)	Separation		
Nominal lengths	d=5mm	d=7mm	d=10mm
2cm	4.85	7.05	10
4cm	4.65	6.75	9.65
5cm	4.65	6.6	9.65

Table 1. Actual Dimensions of Lengths and separations

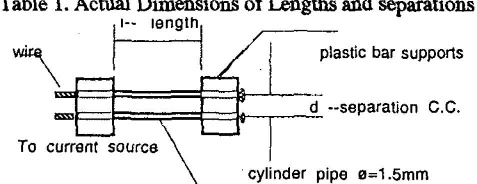

Figure 1. Schematic Drawing of the Elecrode Probe

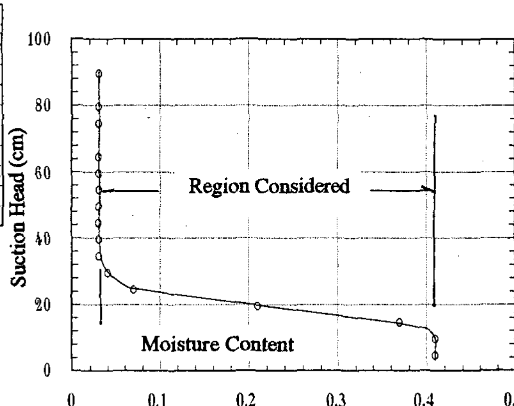

Figure 2. Profile
Suction vs. Moisture Content

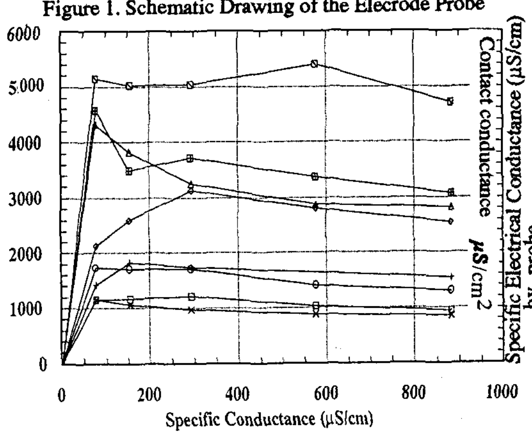

Figure 3. Values of Contact Conductance obtained for each probe in solution Temp=14.5°C

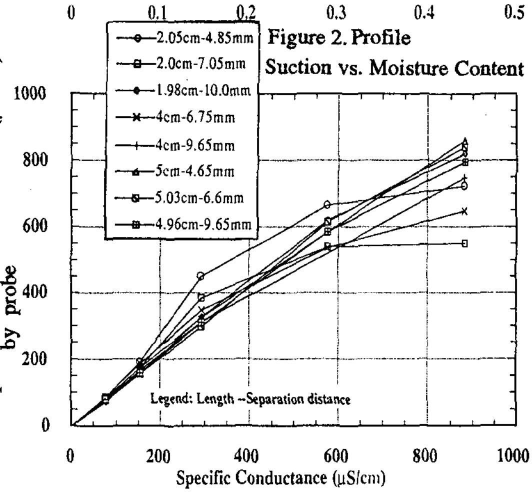

Figure 4. EC of solution as measured by the probe compared to a specific conductance meter

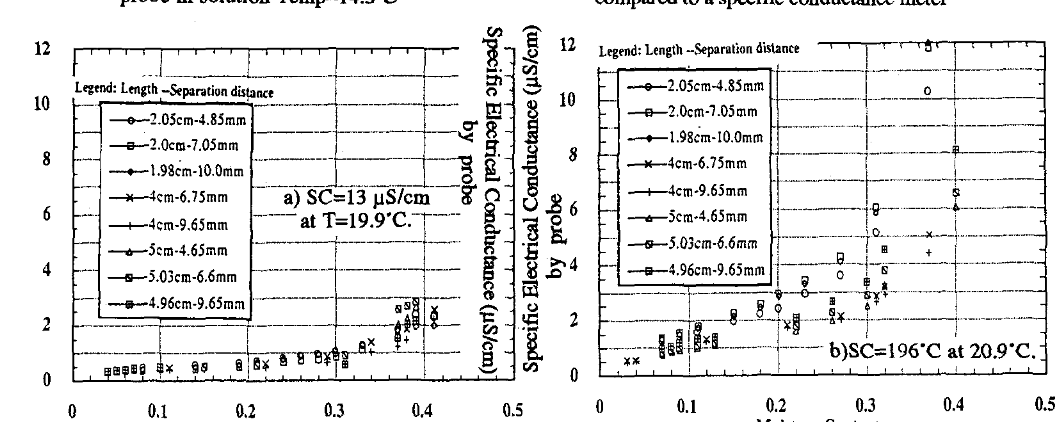

Figure 5. EC measured at varying moisture contents.