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Measuring salinity with WET sensor and characterization of salt affected Soils

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The traditional method of determining soil salinity *i.e.* saturation-extract-electrical conductivity (ECe) requires considerable resources for field sampling and laboratory analysis, which are tedious and time consuming. Consequently, it is ill-suited for characterizing soil salinity in field survey of salt affected soils in regular monitoring programme (Hendricks *et al.* 2002; Corwin and Lesch 2003; Robinson *et al.* 2003). The field survey requires *in-situ* measurement of salinity at field site to ascertain salinity of soils. The development of new technologies such as WET sensor, EC probe and resistivity meter for salinity measurement has revolutionized the way for salinity measurements. Measurements can be taken in the field quickly and it is non-destructive.

WET sensor (developed by Delta-T Devices Ltd., Burwell, U.K.) is used as an analyzing instrument in soil laboratory to measure ECe of saturation paste. The *in situ* measurement of salinity will help not only to monitor the build up of salt over the season, but also to assess how well the reclamation programme is progressing. Balendonck *et al.* (2004) demonstrated that the WET-sensor measures pore water EC *in-situ* with a reasonable accuracy. For the WET sensor to be of practical use, it must provide results comparable to those obtained from the traditional methods. The present study was taken to characterize the physical and chemical characteristics of the soils of a part of Unnao (UP) area and to investigate utility of WET sensor in characterizing direct soil-pore water salinity (ECp) of soil *vis-a-vis* EC of soil saturation extract (ECe) with traditional laboratory method.

Reconnaissance surveys were conducted in the month of November, 2006 and February, 2007. The land with severe salinity (wastelands) had salt encrustation. IRS LISS IV satellite data (standard FCC) of March, 2004 was used to identify transects across the various land-use classes and salt affected soils. A transect of Unnao, Purwa, Achalganj and Bichhia in Unnao district of Uttar Pradesh were taken for reconnaissance survey that corresponds to the area having major problem of salt affected soils. The villages fall in the transect were Ramkhera, Chandigarhi, Bichhia, Achalganj,, Shivkhera, Giankhera, Bhadiyang, Quazikhera, Chamiani, Babukhera, Sasan, Usmian, Bighapur, Kulaha, Chapri and Sheopur.

On the standard FCC, severe salt affected area appeared as bright to dull white tone and in irregular shape. The soil samples from each site at two depths *i.e.* surface (0-25 cm) and sub-surface (25-50 cm) were collected. The site was described in terms of landuse, soil surface aspect and their geographic location using Garmin 12x GPS. Total 51 soil samples were collected from 26 sites. The soil samples were analyzed for physical and chemical properties. Organic matter was estimated by rapid titration method (Walkley and Black 1934). The saturation extracts of the soils were prepared and analyzed for ECe and pH (Richards 1954). For EC extract (ECe), the soil sample was made into a paste and was left for 48 hours, the sample was then put in a vacuum chamber and the moisture extracted, the conductivity of the solute extracted was then measured. Hydrometer method (Day 1965) was used for determining primary particles of sand, silt and clay to find the soil textural class.

The WET-sensor (Delta-T Devices Ltd., 2005) is a portable, frequency domain dielectric sensor that measures permittivity, conductivity and temperature, which can be used for monitoring soil water content and electrical conductivity. It measures the dielectric properties of the soil and calculates water content, electrical conductivity and temperature. The sensor converts the measured dielectric properties into water content over the full range (0-80%) using calibration tables. The WET sensor also calculates pore water conductivity, the electrical conductivity of the water within the pores of the soil (ECp). Temperature is measured using a miniature sensor built into the central rod of the instrument. On inserting the WET sensor into the soil, it generates a 20MHz signal, which is applied to the rod, produces a small electromagnetic field within the soil. The water content, electrical conductivity and composition of the soil surrounding the rods determines its dielectric properties. The WET sensor detects these dielectric properties from their influence on the electromagnetic field and sends this information to HH2 unit. The HH2 measures soil moisture using its calibration tables (water has a dielectric constant of 81 compared to soil 4 and air 1) and calculates the soil pore-water conductivity (ECp).

The soil samples collected during the field surveys were grouped into three landuse classes *viz.*, rice-wheat system, miscellaneous cropping including vegetables, mustard and wheat crops *etc.* and wastelands. The wastelands have salt incrustation on surface and found barren as permanent fallow land. In the wastelands, the pH of the surface soils varied from 8.10 to 10.06, while in sub-surface soils it ranged from 7.89 to 10.15. The pH of surface soil in rice-wheat system was higher than the pH of miscellaneous cropping. The pH was higher in sub-surface soils as compared to surface layer in soils of all land cover classes. Electrical conductivity of saturation extract ranged from 4.38 to 25.67 dSm^{-1} in surface soils and 4.66 to 25.44 dSm^{-1} in sub-surface soils of wastelands. Due to very high salt contents in these soils, no vegetation was able to grow except scant grasses. The ECe of soils was higher in rice-wheat system than the miscellaneous cropping in both surface and sub-surface soils. The ECp values in these soils of various land cover types (Table 1) indicate that ECp varies from 5.51 to 43.58 dSm^{-1} in wasteland soils, whereas it ranged from 0.86 to 13.25 dSm^{-1} in surface and sub-surface soils of rice-wheat system. ECp in miscellaneous cropping varied from 0.77 to 1.76 dSm^{-1}.

The organic matter ranged from 0.15 to 1.50 per cent. It was observed that the organic matter was more in the surface than sub-surface soils. The dominant soil texture was silt loam followed by sandy clay loam and loam. The clay content in wasteland soils ranged from 20 to 28 per cent in surface and 20 to 40 per cent in sub-surface soils.

The results indicated that EC measured with traditional method of saturation extract of soil had quite high correlation ($r^2 = 0.88$) with ECp measured with WET sensor for all soils (Fig. 1). The correlation between ECe and ECp was found to be higher (Fig. 4) for silt loam ($r^2 = 0.94$) followed by loam ($r^2 = 0.80$) (Fig. 2) and for clayey soils ($r^2 = 0.78$) (Fig. 3). It may be attributed as salts got fixed to clay particles and became less freely available in soil pore water for its interaction with the signal generated by WET sensor (Hilhorst 1998). The dielectric constant of salts in soils having relatively high clay content was observed to be less. A high correlation of ECe and ECp was observed for soils of wasteland ($r^2 = 0.90$), followed by rice-wheat system ($r^2 = 0.82$) and miscellaneous cropping ($r^2 = 0.80$) as depicted in figures 7, 5 and 6, respectively. Bakker (2002) also observed similar relationship between EC (1:5) and WET sensor with high correlation ($r^2 = 0.98$). The ECp measured with WET sensor had shown high correlation coefficient ($r^2 = 0.84$) with ECe of the salt affected soils which indicate its higher utility in direct measurement of salinity in characterizing the salt-affected soils.

Table 1. Some basic properties of salt affected soils

S. No.	Land cover	No. of samples	Sampling depth	pH (Saturation extract)		Electrical conductivity (dSm^{-1})				Organic Matter (%)	
						Saturation extract (ECe)		Saturation paste (with WET sensor) (ECp)			
				Range value (Mean)	S.D.	Range value (Mean)	S.D.	Range value (Mean)	S.D.	Range value (Mean)	S.D.
1	Rice-wheat system	9	Surface	7.14-8.75 (7.99)	0.43	0.72-5.25 (2.04)	1.81	0.94-4.20 (2.01)	1.08	0.25-0.88 (0.56)	0.30
		8	Sub-surface	7.75-8.33 (7.99)	0.25	0.61-2.65 (1.90)	1.34	0.86-13.25 (4.01)	4.35	0.15-0.88 (0.42)	0.34
2	Miscellaneous cropping	12	Surface	7.30-9.28 (8.05)	0.50	0.45-1.80 (0.87)	0.42	0.77-1.59 (1.11)	0.30	0.38-1.50 (0.76)	0.33
		12	Sub-surface	7.46-8.47 (8.10)	0.33	0.35-2.80 (0.88)	0.69	0.77-1.76 (1.06)	0.39	0.38-0.88 (0.48)	0.19
3	Wasteland	5	Surface	8.10-10.06 (9.02)	1.12	4.38-25.67 (13.82)	9.66	5.51-33.76 (17.66)	11.28	0.25-0.73 (0.38)	0.18
		5	Sub-surface	7.89-10.15 (9.04)	0.91	4.66-25.44 (10.93)	8.67	8.34-43.50 (18.63)	14.65	0.15-0.63 (0.46)	0.30

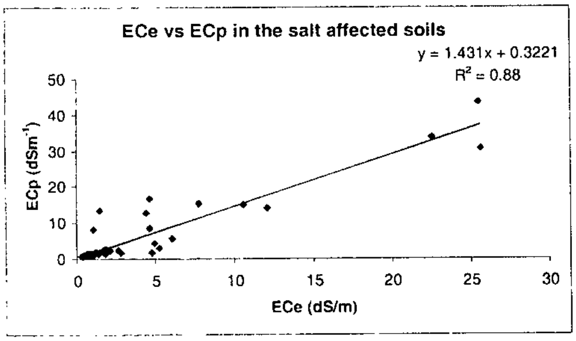

Fig. 1. ECe vs ECp in salt affected soils

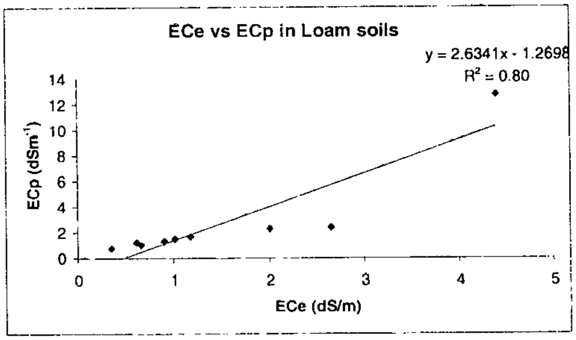

Fig. 2. ECe vs ECp in loam soils

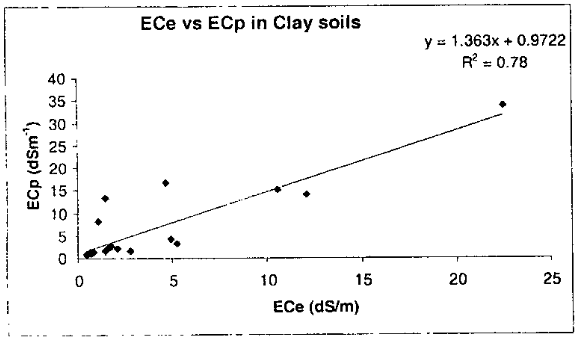

Fig. 3. ECe vs ECp in clay soils

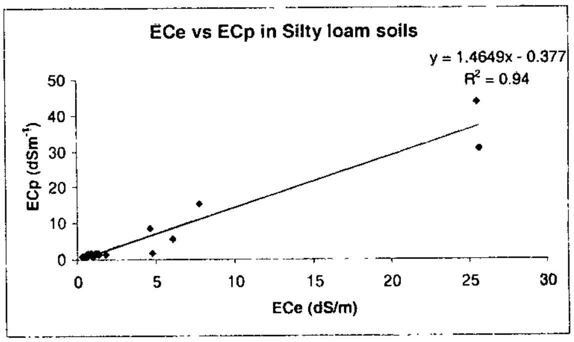

Fig. 4. ECe vs ECp in silty loam soils

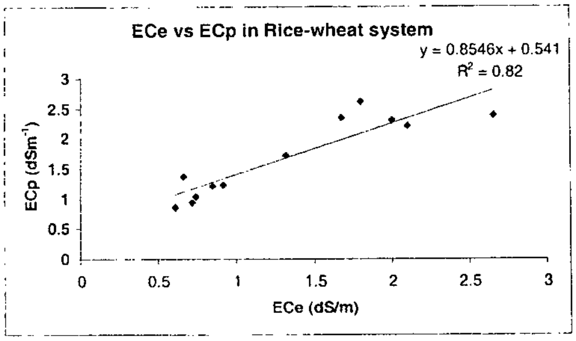

Fig. 5. ECe vs ECp in rice-wheat system

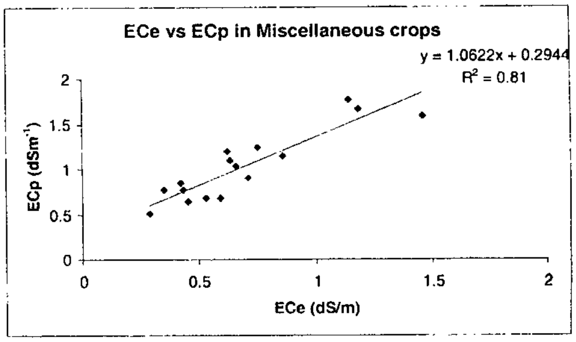

Fig. 6. ECe vs ECp in miscellaneous crops

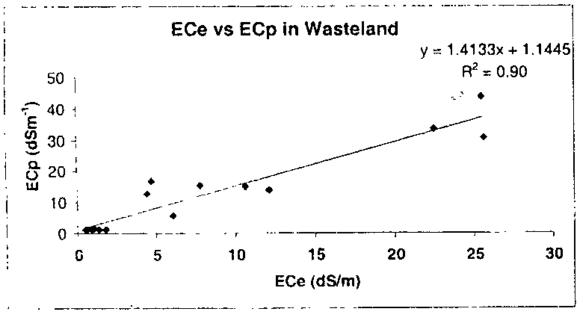

Fig. 7. ECe vs ECp in wasteland

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