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Use of electrical conductivity instead of soluble salts for soil salinity monitoring in Central Asia

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Abstract. The USSR classifications of soil salinity used in Central Asia was based on laboratory measurement of the total dissolved (toxic) salts or the chloride ion concentration in the soil water extracts (soil:water = 1:5). Current practices, however, start to differ between the republics because of different levels of acceptance of international literature. This change in practice is triggered partly by the cost of the laboratory measurements. The use of different methods next to each other affects the reliability of information on salinity. This paper promotes the used of the UC of a 1:1 soil-water suspension was found to give the best fit to the soil extract with leaching of calcium and sulfate ions. The cost of data collection is significantly lower than that of the 1:5 extract.

Key words: salinity, electrical conductivity, laboratory, data, Central Asia

Introduction

Of the 7.8 million hectares of irrigated land in Central Asia, about 50% is saline, 29% of which has a strong to moderate degree of salinity (Table 1). Table 1 shows an increase of salinity sensitive land. This increasing salinity of the irrigated soils is one of the main reasons for the current decrease in agricultural productivity in Central Asia. Causes of soil salinity are:

1. Cultivation of naturally-saline lands (e.g. Golodnaya Steppe);
2. Rise in secondary salinity because of the inflow of mineralized (saline) groundwater from higher plateaus with intensive irrigation;
3. Increase in the salt content of irrigation water because of the disposal of drainage water into irrigation canals.

Three years observations of soil salinity in Central Asia, implemented through the Water Use and Farm Management Survey (WUFMAS) subproject of the TACIS sponsored WARMAP project, show the trend of growth of severely and moderately saline soils under current agricultural practices (Table 1 and Figure 1).

Table 1. Change of percentage of fields by soil salinity (WUFMAS data).

Soil salinity level	1996	1998
Non saline	48	50
Slightly saline	35	21
Moderately saline	12	17
Highly and severely saline	5	12
Total: moderately and severely saline	17	29

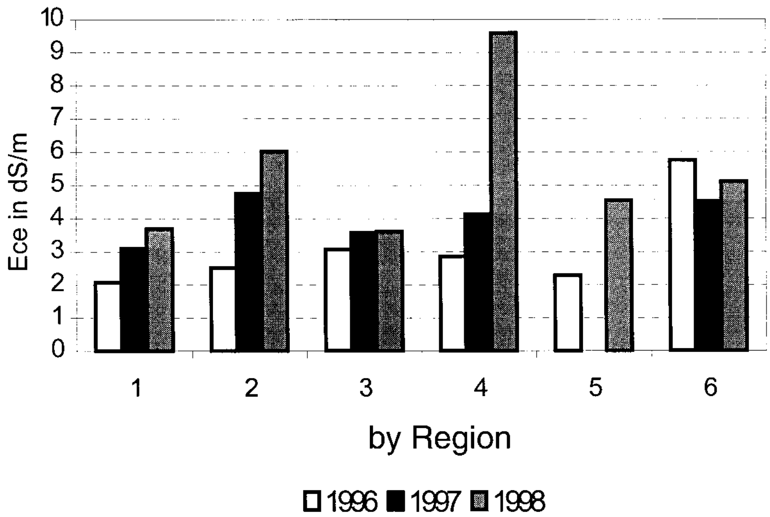

Figure 1. Change of soil salinity in Uzbekistan farms according to WUFMAS project (mean from 20 fields).
1 – Surkhandarya; 2 – Syrdarya; 3 – Khorezm; 4 – Karakalpakstan; 5 – Ferghana; 6 – Bukhara.

Salinity monitoring in Central Asia

The USSR classifications of soil salinity used in Central Asia was based on the measurement of total dissolved solids and the sum of soluble (toxic) salts or the chloride ion concentration in the soil water extracts (soil:water = 1:5). At present, organizations responsible for soil salinity monitoring experience a number of difficulties including shortage of funds and qualified personnel. Furthermore, the approach to soil salinity assessment starts to differ between the republics because of different levels of acceptance of international literature. Both factors significantly affect the reliability of information obtained at routine observations.

Table 2. FAO (USDA) classification used for soil salinity assessment.

Salinity level	Degree of crops sensitivity	Electro-conductivity of soil saturated extract ECe at t = 25°C (dS/m)
non saline	very sensitive crops	0–2
low salinity	sensitive crops	2–4
mild salinity	mildly sensitive crops	4–8
high salinity	mildly resistant crops	8–16
severe salinity	resistant crops	>16

To facilitate salinity monitoring it is proposed to assess soil salinity on the basis of electro-conductivity measurements. This method has the following advantages above the USSR method:

- fast results;
- applicable in the field;
- possibility to cover large areas;
- sufficient accuracy due to the measurement replication;
- cost effectiveness compared to the laboratory measurements.

Experiments

According to the FAO (Landon 1991; Agricultural Compendium 1989), soil salinity is assessed by the measurement of the electro-conductivity of saturated soil extracts (Table 2). Saturated soil extracts can be produced only in an adequately equipped laboratory. That is why electro-conductivity is usually measured in soil-water suspensions and leachates rather than in saturated extracts.

For soil salinity assessment and the conversion to ECe, the measured values of electro-conductivity of the soil suspensions and the leachates are multiplied by an empirical factor K:

$$\text{ECe} = \text{KEC}_{1:1(1:2.5,1:5)}$$

Where $\text{EC}_{1:1(1:2.5,1:5)}$ is the electro-conductivity of the soil water suspensions (leachates) with the corresponding soil to water ratio. International literature gives formulae for the calculation of the K factor and its recommended empirical values. For example Landon (1991) gives the following values:

Table 3. Electro-conductivity of soil extracts, suspensions and leachates measured at the G. Gulyam farm in the Syr Darya region.

# of section	Depth cm	ECe	$EC_{1:1}$	$EC_{1:2.5}$	$EC_{1:5}$
		dS/m			
Section 1	0–70	2.58	0.43	0.33	0.16
	70–96	4.08	0.92	0.66	0.28
	96–123	4.26	1.58	2.03	1.46
	123–200	3.48	1.31	1.68	1.21
	200–350	3.80	1.07	1.31	0.84
	350–450	3.55	No data	No data	0.46
Section 2	0–53	4.44	1.55	1.85	1.40
	53–83	3.75	1.68	2.11	1.50
	73–230	3.97	1.06	2.11	0.85
	230–250	3.27	No data	No data	0.83
	250–415	4.52	1.38	1.22	1.27
Section 3	0–44	9.90	2.44	2.44	1.56
	44–88	10.22	2.86	3.02	1.73
	88-150	7.33	2.04	1.75	1.54
	150–300	7.35	1.63	1.26	0.80
	300–370	9.94	2.36	2.03	1.47
Section 4	0–44	18.48	4.57	3.90	2.10
	44–61	14.12	5.01	4.11	2.04
	61–102	16.43	3.77	3.42	1.98
	102–150	No data	3.22	3.14	1.86
	150–230	6.56	2.15	2.35	1.60
	230–300	4.38	1.62	1.79	1.44

Table 4. Conversion matrix of measured electrical conductivity.

	EC_e	$EC_{1:1}$	$EC_{1:2.5}$	$EC_{1:5}$
EC_e	1			
$EC_{1:1}$	0.94	1		
$EC_{1:2.5}$	0.84	0.94	1	
$EC_{1:5}$	0.72	0.83	0.89	1

$$ECe = 6.4\ EC_{1:5}$$
$$ECe = 2.2\ EC_{1:1}$$

And the Agricultural Compendium (1989) gives:

$$1000\ Ece = (500000\ EC_{1:5})/SP$$

where SP is the soil saturation (percent by weight) normalized by volume (empirically determined).

Soils in Central Asia have their distinct special properties: silt fraction is predominant and a high content of divalent salts. Thus there is a need to refine the K factor for local conditions for successful conversion to the FAO soil salinity assessment based on the measurement of electro-conductivity.

Results

The Laboratory of Soil Studies of SANIIRI carried out research to assess soil salinity in Central Asia by electro-conductivity measurements. The laboratory measured the electro-conductivity of saturated soil extracts, pastes, suspensions (1:1), and leachates (1:5) and determined chemical composition of soil solutions and water extracts. Soils of four genetic types were used with ECe values in the range of 2.5 to 49 dS/m and with total dissolved solids content (TDS) in the range of 3.0 g/l to 50 g/l.

The EC of a 1:1 soil:water suspension was found to give the best fit to the soil extract with leaching of calcium and sulfate ions in a 1:5 extract (Figure 2).

The above shows that, for Central Asia, soils with high content of divalent ions, the EC can be most conveniently measured in water soil suspensions with a 1:1 ratio ($EC_{1:1}$). Figure 3 shows an example of the comparison between the EC_e data and the local TSS classification. In this context the value of $TSS = TDS - [CaSO_4 + Ca(HCO_3)_2]$.

Electro-conductivity measurements were made on a representative silty loam soil (SL) from a farm in the Syr Darya region of Uzbekistan. Soil salinity was measured with suspension ratios of 1:1, 1:2.5 and water extracts of 1:5. Tables 2 and 3 show that for this type of soil a suspension ratio of 1:2.5 can be used equally well as a 1:1 suspension. It gave high correlation factors and close values for the correction factor K that was 3.6 in both cases. This shows that some inaccuracy in the soil over water ratio, which is common in field measurements, does not affect the accuracy of the data. For the

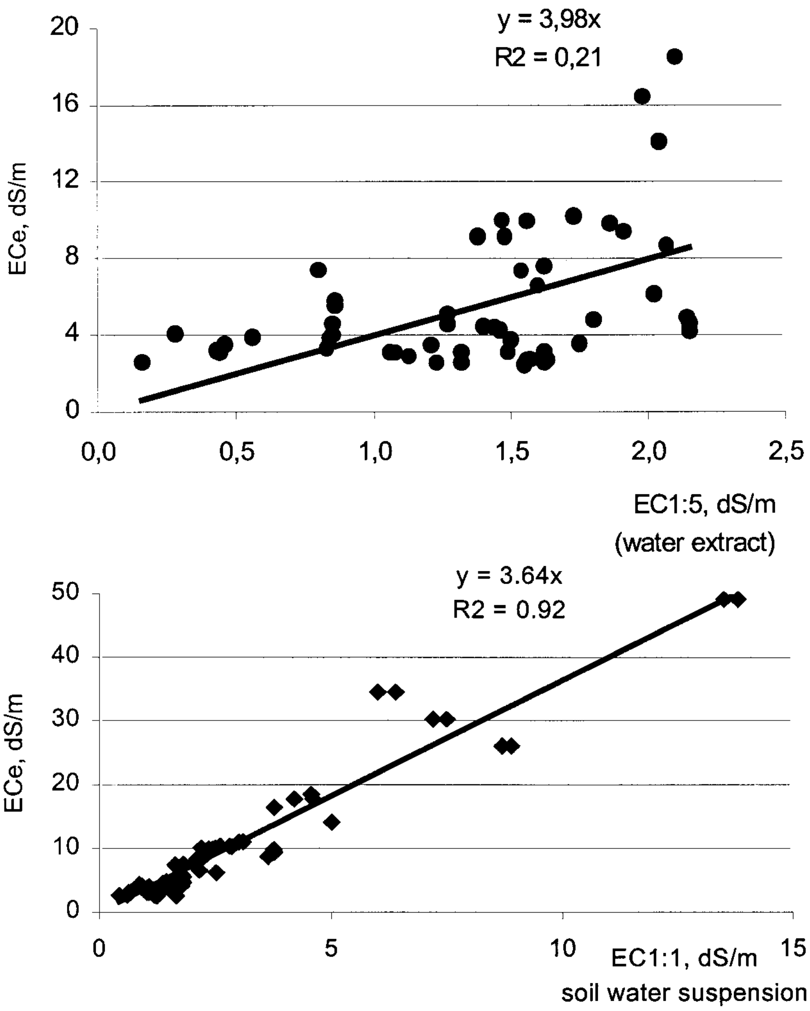

Figure 2. Electro-conductivity of saturated soil extracts, suspensions and leachates.

same conditions, sufficiently high correlation was found between the electro-conductivity of the saturated soil extract (EC_e) and that of water extract 1:5. The K factor value was also quite high, being equal to 5.6.

Conclusion

Laboratory studies justify large-scale application of the electro-conductivity measurement method in soil salinity monitoring by specialised agencies in Central Asia. Currently the authors promote the method at the ministries of

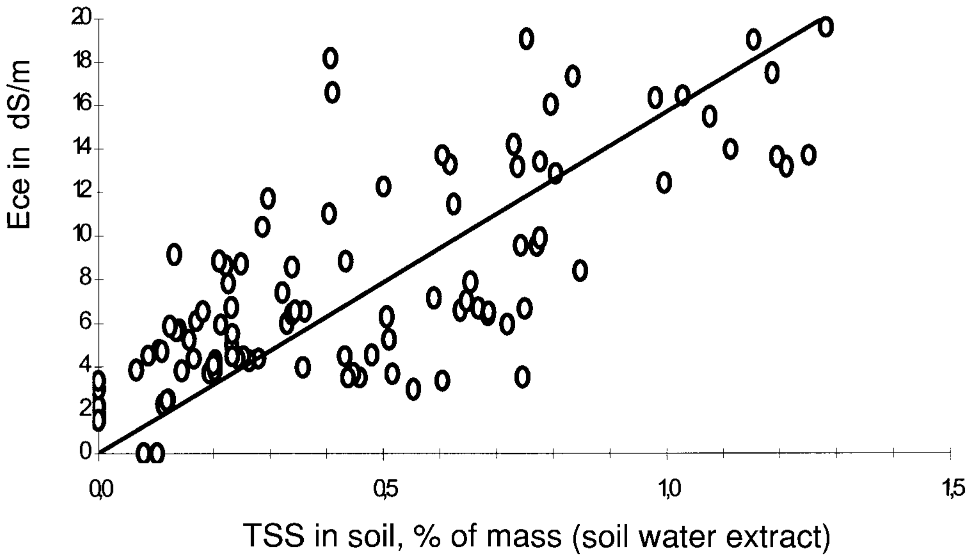

Figure 3. Relationship between the EC_e and TSS methods of salinity classification.

agriculture in the region and water industry as well as by individual farmers. They carry out workshops on the use of a SANIIRI-designed instrument for soil electro-conductivity measurement.

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