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Evaluation of Diagnostic Techniques for Appraising Salinity of *Bhal-Nal* Soils of Gujarat Using Various Dilute Aqueous Extracts

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ABSTRACT

For the appraisal of salinity, 41 surface soil samples were collected from the salt-affected soils of *Bhal-Nal* area (Gujarat). Highly significant correlations (r = 0.9897 to 0.9918) between electrical conductivity of saturation extract (ECe) and electrical conductivity of different soil : water extracts (EC_1, EC_2, EC_5) were observed, hence the regression equations were computed. Owing to very high correlations with a minimum standard error of estimate for equations of 1:1 and 1:2 aqueous extracts, the prediction of ECe in the range of 2.0 to 82.5 dSm^{-1} from either EC_1 or EC_2 with a greater precision was accomplished. Using regression equations, the corresponding limits of EC_1, EC_2 and EC_5 as well as distribution of samples (%) in each salinity group were worked out. The pattern of distribution of samples under EC_1 and EC_2 was almost similar to ECe.

Looking to the very high correlations, minimum standard error of estimate and almost same distribution of samples (%) in cases of EC_1 and EC_2, their limits can be utilized in lieu of ECe for salinity appraisal, however, EC_2 may be preferred over EC_1 because of its simplicity and rapidity.

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INTRODUCTION

The measurement of the electrical conductivity of the saturation extract (ECe) of the soil has been recognised quite extensively for the accurate appraisal of soil salinity with respect to plant response. The determination of ECe is, however, time consuming and tedious. On the other hand the dilute aqueous extracts of the soil can be easily employed for extensive analytical work. Although, the changes in the soil : water ratio used for the extraction of soluble salts affects the determination due to varying solubilities of different salts present in the soils and ion exchange reactions between the clay complex and the solution. High degree of correlation has, however, been obtained between ECe and EC of dilute soil solutions of the salt-affected soils of various regions of India (Carpena *et al.*, 1968; Sonneveld and Ende 1971; Gupta and Hanks, 1972 and Singhla *et al.*, 1974). Such systematic work has been lacking on soils of Gujarat. With a view to appraise the salinity using EC of various soil aqueous extracts of *Bhal-Nal* area of Gujarat, the present investigation was undertaken.

MATERIALS AND METHODS

From the salt-affected area of *Bhal-Nal* (Dholka taluka), 41 soil samples (0-30 cm) were collected in June, 1982 for the purpose of the present research work. The soils consist mainly of recent marine sediments. Most of the soils have loam to clay texture. Some physic

chemical properties like electrical conductivity of saturation and various aqueous extracts, saturation percentage, individual soluble cations, clay, O. M., $CaCO_3$, pH, CEC and ESP (Table-1) were determined using standard methods. Total soluble cations (TSC) were determined by adding up the individual cations and expressed as cmol(p^+) kg^{-1}. The soil samples were categorized into three salinity groups viz., low (ECe, < 2 dSm^{-1}), medium

TABLE 1

Some physico-chemical properties of soils of *Bhal-Nal* area.

Particulars	*Range*	*Mean*
Saturation percentage	23.42-72.06	49.53
Clay (%)	3.72-47.64	25.26
Organic matter (%)	0.19-0.94	0.65
$CaCO_3$ (%)	Traces-24.25	7.46
pH_s	7.80-8.45	8.15
ECe (dSm^{-1})	0.85-82.50	9.19
CEC (cmol (p^+) kg^{-1})	5.66-41.35	22.65
ESP	8.37-71.27	30.97

TABLE 2

Average EC (dSm^{-1}) and TSC (cmol (p^+) kg^{-1}) of various soil : water extracts.

Particulars	*Soil group*			*Overall (41)*
	Low salinity (20) ECe < 2dSm^{-1}	*Medium salinty (12) ECe 2-8 dSm^{-1}*	*High salinity (9) ECe > 8dSm^{-1}*	
ECe	1.21	3.58	34.42	9.19
EC_1	0.94	1.95	21.08	5.66
EC_2	0.79	1.58	13.19	3.74
EC_5	0.47	0.77	6.09	1.79
TSC se	1.04	2.96	33.93	8.82
TSC_1	1.12	2.95	31.98	8.43
TSC_2	2.03	4.48	37.89	10.62
TSC_5	2.71	4.95	37.02	10.90

Figures in parenthesis indicate the number of samples.

(ECe, 2-8 dSm^{-1}) and high (ECe, > 8 dSm^{-1}). Statistical analysis was carried out on a computer.

RESULTS AND DISCUSSION

The data (Table-2) revealed that the average electrical conductivities of the soils studied were 9.19, 5.66, 3.74 and 1.79 dSm^{-1} in the saturation, 1:1, 1:2 and 1:5 soil : water extracts, respectively. As expected, the EC of aqueous extract decreased with increase in soil : water ratio, being maximum in saturation extract. The EC of saturation extract was found 1.62, 2.46 and 5.13 times higher than EC of 1:1, 1:2 and 1:5 soil : water extracts, respectively. Further, it was also noted that the EC of all the aqueous extracts increased with increase in salinity, being highest in high salinity followed by medium and low salinity groups.

The data on total soluble cations (TSC) presented in Table-2 revealed that there is an abrupt change in TSC (cmol (p^+) kg^{-1}) of 1:2 and 1:5 soil : water extracts while going from saturation to 1:5 aqueous extracts. The per cent increase in TSC_2 over TSC_1 or TSC_{SE} was 81.3, 51.9 and 18.5 under low, medium and high salinity groups, respectively. The increase in TSC at higher soil : water ratio might be due to dissolution of sparingly soluble salts like $CaSO_4$, $CaCO_3$ and $MgCO_3$ (Reitemeier, 1946; Paul *et al.*, 1966: and Black, 1968). Further, it is observed that the per cent increase in TSC_2 decreases with the increase in salinity indicating low solubility of sparingly soluble salts at higher salinity.

The correlation coefficients of EC1, EC2 and EC5 with ECe for different salinity groups as well as overall soils were worked out and are reported in Table-3.

TABLE 3

Regression equations and correlation coefficients of EC_1, EC_2 and EC_5 with ECe and their statistical tests of significance.

Soil : Water ratio	*Soil group*	*Regression equations (Y=a + b X)*	*Correlation coefficients (r)*	*Standard error of estimate ($S_{y.x}$)*
1:1	Low salinity (20)	Ece = 0.4643 + 0.7905* EC_1	0.4553*	0.3643
	Medium salinity (12)	Ece = 1.1577 + 1.2466* Ec_1	0.6739*	0.4328
	High salinity (9)	Ece = 2.1331 + 1.5315** Ec_1	0.9822**	0.1108
	Overall (41)	Ece = 0.2369 + 1.5836** Ec_1	0.9904**	0.0354
1:2	Low salinity (20)	Ece = 0.7024 + 0.6414 Ec_2	0.4277	0.3191
	Medium salinity (12)	Ece = 1.1192 + 1.5645 Ec_2	0.5625	0.7277
	High salinity (9)	Ece = 1.5879 + 2.4885** Ec_2	0.9813**	0.1845
	Overall (41)	Ece = -0.4457 + 2.5764** Ec_2	0.9897**	0.0597
1:5	Low salinity (20)	Ece = 1.1797 + 0.0589 EC_5	0.0219	0.6544
	Medium salinity (12)	ECe = 1.0381 + 3.3020 EC_5	0.5698	1.5078
	High salinity (9)	ECe = 0.2576 + 5.6059** EC_5	0.9855**	0.3647
	Overall (41)	ECe = -1.0929 + 5.7343** EC_5	0.9918**	0.1183

Figures in parenthesis indicate the number of samples.

* Regression coefficient (b) and correlation coefficient (r) significant at 5 per cent level.

**Regression coefficient (b) and correlation coefficient (r) significant at 1 per cent level.

Highly significant correlation coefficients (Table-3) between ECe and EC of different soil : water extracts were observed in high salinity (r = 0.9813 to 0.9855) and overall (r = 0.9897 to 0.9918) soil groups. The correlation values improved with the increase in salinity. These results are in line with those reported by Carpena *et al.* (1968), Gupta *et al.* (1969), Gupta and Hanks (1972) and Singhla *et al.* (1974). The poor correlation values for ECe with EC_2 and EC_5 under low and medium salinity groups could be attributed to irregular dissolution pattern of different quantities of sparingly soluble salts present in soils (Table-2).

The regression eqations for the prediction of ECe from EC of the various aqueous extracts were worked out and are presented in Table-3. It is revealed that the regression coefficients (b values) between the ECe and EC of the various soil : water extracts were highly significant (1% level) in high salinity and overall soil groups, while in low and medium salinity groups, the regression coefficients were significant at 5 per cent level. The values of regression coefficient (b) increased with the increase in salinity. Carpena *et al.* (1968) also reported that as salinity increased from 1.4 to 16.1 dSm^{-1}, the regression coefficients also increased. The data further revealed that in case of overall soils, the correlation coefficient was very high with a minimum standard error of estimate, particularly for the equations for 1:1 and 1:2 soil : water extracts. Hence, the prediction of ECe (2.0 to 82.5 dSm^{-1}) from either EC_1 or EC_2 with greater precision is possible by using the regression equation for overall soils as the sample size is high.

Classification of soils for salinity appraisal

Using regression equations for overall soils, as it gave best fit in the range of ECe 2.0 to 82.5 dSm^{-1} in the different aqueous extracts, the limits of EC_1, EC_2 and EC_5 were calculated for different salinity groups as suggested by Scofield (1942). Distribution of samples (%) in each salinity group for the different aqueous extracts was also worked out (Table-4).

TABLE 4

Classification of soils of *Bhal-Nal* area, based on EC (dSm^{-1}) of different soil : water extracts.

	*Designation** / *Particulars*	*Very low saline*	*Low saline*	*Moderate saline*	*Saline*	*Highly saline*
I	**Saturation Extract**					
	Limits of ECe*	< 2.00	2.00—4.00	4.00—8.00	8.00—16.00	>16.00
	Distribution of samples (%)	48.78	17.07	12.20	9.75	12.20
II	**1:1 Soil : Water Extract**					
	Limits of EC_1	< 1.25	1.25—2.25	2.25—5.00	5.00—10.00	>10.00
	Distribution of samples (%)	48.78	19.51	12.20	7.31	12.00
III	**1:2 Soil : Water Extract**					
	Limits of EC_2	< 1.00	1.00—1.75	1.75—3.25	3.25—6.50	>6.50
	Distribution of samples (%)	46.34	21.95	12.20	7.31	12.20
IV	**1:5 Soil : Water Extract**					
	Limits of EC_5	< 0.55	0.55—0.90	0.90—1.75	1.75—3.50	>3.50
	Distribution of samples (%)	41.47	26.83	14.64	7.31	9.75

* Salinity classes are based on Scofield scale.

The data presented in Table-4 revealed that 48.78, 17.07, 12.20, 9.75 and 12.20 per cent samples were found under very low saline, low saline, moderately saline, saline and highly saline classes, respectively in case of saturation extract, considering the Scofield scale. More or less the same distribution of samples was observed in cases of 1:1, 1:2 and 1:5 soil : water extracts.

Corresponding to the ECe in the Scofield scale, the limits of conductivity (dSm^{-1}) for EC_1 were : < 1.25, 1.25- 2.25, 2.25- 5.00, 5.00-10.00 and > 10.00 : EC_2 : < 1.00, 1.00-1.75, 1.75-3.25, 3.25-6.50 and > 6.50 ; EC_5 : < 0.55, 0.55-0.90, 0.90-1.75, 1.75-3.50 and > 3.50 for very low saline, low saline, moderately saline, saline and highly saline classes, respectively.

Many research workers have used 1:2 soil : water extract for salinity classification (Hogg and Henry, 1984 ; Mc Kenzie *et al.*, 1983; Sonneveld and Ende, 1971 ; Jackson, 1968). On the basis of EC_2, the soils were evaluated (Muhr *et al.*, 1965) as normal, critical for germination, critical for the growth of salt-sensitive crops and severely injurious to crops if EC_2 were < 1, 1-2, 2-3 and > 3 dSm^{-1}. Similarly, Jackson (1975) suggested the limits of EC_2 extract for fine textured soils as < 0.75, 0.75-1.00, 1.00-2.00, 2.00-3.00 and 3.00-4.00 dSm^{-1} for non-saline, very slightly saline, moderately saline, strongly saline and very strongly saline classes, respectively.

Thus, limits of EC_1 and EC_2 can be safely utilized for predicting ECe due to very high values of correlation coefficients (r = 0.9904 and 0.9897) and least standard error of estimate ($S_{y.x}$ = 0.0354 and 0.0597) in their regression equations. However, EC of 1:2 extract may be preferred for appraising salinity of soil in extensive analytical work, as it is easy, rapid and give accurate determination.

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