https://doi.org/10.29321/MAJ.10.A03004

Madras agric. J. 66 (10) : 643-648, Oct., 1979.

The Effect of Dilution on Soluble and Exchangeable Sodium in Salt Affected Soils*

K. F. KURI[1] and T. SESHAGIRI RAO[2]

The effect of dilution on soluble and exchangeable sodium in salt affected soil was studied. An attempt was made to establish quantitative relationship between soluble sodium fraction and dilution. In all the soil profiles, the relationship was found to be fairly linear. On dilution, the activities of soluble calcium and magnesium increased resulting in the displacement of exchangeable sodium and consequent decrease in ESP values. The results suggest that the 'valence-dilution' principle could be used successfully in the reclamation of salt affected soils.

The analysis of saturated extract of soil for electrical conductivity and other chemical constituents is indispensable for soil salinity appraisal. But in heavy textured soils, rich in expanding silicate clay minerals, it is extremely difficult to get sufficient amount of saturated extract for analysis. The problem will be more serious if the soil is sodic. It is more convenient to prepare soil extracts by using wide soil to water ratios. If, however, a quantitative relationship can be established between soluble ions and dilution, then the concentration at any desired soil to water ratio may be obtained by extrapolation. In this paper an attempt is made to establish such a relationship.

MATERIAL AND METHODS

Two black soil profiles (Sureban and Katkol) from the Malaprabha Right Bank Project area, one red soil (Madarkhandi) from the Ghataprabha Left Bank Project area and one mixed soil (Nirmanvi) from the Tungabhadra Left Bank Project area, (all in Karnataka) were selected for the study. From each soil profile, three samples were collected at 0-30, 30-60 and 60-90 cm depths. The physical and chemical properties of the soils relevant to the present investigation were analysed following the standard procedures.

For the preparation of water extracts, 20 g of air-dried soil was equilibrated with 20, 60, 100, 140 and 200 ml of distilled water, separately, to get soil to water ratios of 1 : 1, 1 : 3, 1 : 5, 1 : 7 and 1 : 10, respectively. The amount of air-dry moisture present in the soil was taken into consideration when adding distilled water. After shaking the soil for two hours, the suspension was filtered through a Buchner funnel under suction and the extract

* Part of M. Sc. (Ag.) thesis of the first author

1. Assistant Agricultural Officer, Mundargi, Dharwad dist.
2. Professor of Soil Science, College of Agriculture, DHARWAD

was analysed for the various constituents. In the equilibrated soils, the exchangeable cations were determined after romoving excess salts by washing with 80 per cent alcohol. All the equilibrations were carried in duplicate.

RESULTS AND DISCUSSION

The data on some of the physical and chemical properties of the soils are given in Table I. It may be noted that Nirmanvi soil is coarse textured, Sureban and Katkol soils are fine textured and the texture of Madarkhandi soil is intermediate to the above groups. All the soils are both saline and alkaline througeout the depth of sampling. Sodium and chloride are the dominant ions in the water extract. Excepting Nirmanvi soil, the others contain significant amounts of water soluble calcium and/or magnesium.

In relating the changes of soluble sodium on dilution, Levy and Feigenbaum (1977) found soluble sodium fraction as a useful parameter and defined the latter term as follows :

$$SSF = \frac{SS}{Ex.S} \quad ----- \quad (1)$$

where SSF = Soluble sodium fraction

SS = Soluble sodium in meq/100 g.

Ex.S = Extractable sodium in meq/100 g.

The extractable sodium is further defined as :

$$Ex.S = SS + ES \quad ---- \quad (2)$$

where ES = exchangeable sodium in meq/100 g.

Similarly, the changes in exchangeable sodium may be followed through the change in ESP values. The ESP dilution/ESP original ratio is another useful index for following the changes in exchangeable sodium. From the analytical data, the above mentioned parameters were calculated and the data are given in Table II. The decrease in EC values with increase in soil to water ratios may be explained being due to the effect of dilution. In all cases the EC values decreased significantly on dilution.

With regard to effect of dilution on SSF in different soils it may be noted that in all cases the SSF values increased on dilution. The enrichment of soluble sodium may be due to the increase in the amount of water added to the soil as well as the release of Na from the exchangeable sites replaced by divalent cations. The later conclusion is corroborated by the decrease in ESP values on dilution. The operation of ratio law on dilution may be clearly noticed in the result. In consonance with the nature of salt distribution in the soil body, the SSF values have decreased with depth in all the soils. From the nature of the relationship it may be observed that the intercept of coarse textured soil is higher than fine textured soil. Making the assumption that SSF is a linear function, Levy and Feigenbaum (1977) proposed a linear equation :

$$SSF = aX + SSF_o \quad ------ \quad (3)$$

in which, X = amount of water added to the dry soil

a = rate at which SSF changes on dilution

TABLE 1. Some physical and chemical characteristics of the soils.

	Machanical analysis					EC		Water soluble irons (SATURATED EXTRACT)							Exchangeable cation				
Depth Cm.	Coarse sand %	Fine sand %	Silt %	Clay %	$CaCO_3$ %	m.mhos per cm. at 25°C.	pH	Na	Mg me/1	Cl	SO_4	CO_3	HCO_3	CEC	Na me/100 g.	K		Ca+Mg	ESP
								NIRMANVI											
0-30	61.9	27.5	4.5	4.9	4.5	26.0	8.0	258.7	3.9	1.7	258.9	1.8	—	3.8	10.9	3.8	0.5	6.6	35
30-60	61.1	17.1	10.7	8.8	8.5	12.5	8.4	133.0	3.3	1.1	132.3	1.7	0.6	0.5	16.4	8.5	0.5	7,4	48
60-90	61.5	18.1	10.8	9.0	2.6	16.5	8.5	172.2	3.3	2.8	172.5	0.9	0.9	4.2	19.0	9.4	0.7	8.9	49
								MADAR KHANDI											
0-30	42.1	4.5	10.0	41.5	1.3	30.0	7.5	200.4	50.1	46.8	284.7	9.3	—	2.7	46.4	13.6	0.9	31.9	29
30-60	47.6	3.4	11.0	38.0	2.0	20.2	8.1	153.3	25.4	20.3	190.9	4.8	—	3.9	42.4	14.4	1.1	26.9	34
60-90	50.1	3.3	10.8	35.7	3.5	10.0	8.2	95.5	10.0	4.4	102.4	3.1	—	4.4	36.1	11.4	1.0	23.7	32
								SUREBAN											
0-30	3.5	11.6	33.8	48.5	10.0	49.5	8.0	420.9	39.6	31.4	500.1	7.9	—	3.0	41.0	20.6	2.2	18.2	50
30-60	5.9	10.1	21.0	60.3	11.0	19.5	8.1	200.6	16.5	6.8	200.5	2.8	—	3.8	47.3	22.3	2.3	22.7	47
60-90	6.4	7.3	18.2	65.6	13.7	9.5	8.0	112.4	5.9	2.4	114.2	1.5	—	5.1	53.8	22.3	1.9	29.6	41
								KATKOL											
0-30	10.0	2.9	29.5	56.5	9.3	21.0	8.0	172.8	15.4	11.6	192.2	4.4	—	2.9	47.0	34.2	0.9	11.9	73
30-60	9.0	4.2	21.2	63.5	12.0	13.7	8.1	108.7	12.1	10.5	120.8	4.7	—	2.3	62.0	34.2	1.0	27.8	55
60-90	9.1	4.9	19.3	65.3	1.22	6.0	8.1	41.3	3.9	1.2	41.5	1.9	—	2.9	58.8	35.2	1.0	22.5	60

TABLE II. Electrical conductivity (EC) in m.mhos/cm at 25°C, soluble sodium (SS) in meq/litre, SSF, ESP and ESP $_{dilute}$/ESP $_{original}$ values at various dilutions

Depth	EC	SS	SSF	ESP	ESP_d/ESP_o	EC	SS	SSF	ESP	ESP_d/ESP_o
		NIRMANVI					MADARKHANDI			
		1 : 1						1 : 1		
0—30	9.1	10.7	0.76	31	0.88	15.4	15.2	0.54	28	0.97
30—60	6.6	7.1	0.48	46	0.95	8.9	8.6	0.46	24	0.70
60—90	8.1	10.0	0.52	48	0.98	3.8	3.4	0.30	22	0.69
		1 : 3						1 : 3		
0—30	3.7	10.8	0.77	30	0.86	8.5	21.2	0.74	16	0.55
30—60	3.2	9.7	0.62	37	0.77	3.8	11.2	0.55	22	0.65
60—90	3.5	11.3	0.57	45	0.92	2.1	5.4	0.42	21	0.66
		1 : 5						1 : 5		
0—30	2.4	13.1	0.84	34	0.97	5.7	19.6	0.75	15	0.52
30—60	2.0	11.8	0.68	34	0.71	2.4	11.4	0.60	18	0.53
60—90	2.4	13.9	0.63	43	0.88	1.4	5.8	0.47	18	0.56
		1 : 7						1 : 7		
0—30	1.9	11.5	0.87	17	0.48	4.2	25.5	0.80	14	0.48
30—60	1.7	11.4	0.68	32	0.67	1.8	11.1	0.61	17	0.50
60—90	1.7	13.2	0.63	42	0.86	1.1	6.2	0.49	18	0.56
		1 : 10						1 : 10		
0—30	1.3	12.3	0.92	10	0.28	3.0	25.6	0.83	11	0.38
30—60	1.1	12.6	0.73	28	0.58	1.4	11.4	0.64	15	0.44
60—90	1.4	16.3	0.72	34	0.69	0.8	6.7	0.52	17	0.51
		SUREBAN					KATKOL			
		1 : 1						1 : 1		
0—30	22.3	20.2	0.52	46	0.92	9.3	10.3	0.29	53	0.73
30—60	5.3	5.2	0.24	34	0.72	7.0	8.1	0.26	37	0.67
60—90	5.1	4.0	0.19	31	0.76	3.7	3.4	0.12	42	0.70
		1 : 3						1 : 3		
0—30	14.5	52.8	0.79	35	0.70	4.5	11.8	0.34	49	0.67
30—60	5.3	13.2	0.45	34	0.72	3.7	10.2	0.31	34	0.62
60—90	2.8	8.3	0.35	29	0.71	1.7	5.2	0.18	40	0.67
		1 : 5						1 : 5		
0—30	9.7	50.1	0.80	30	0.60	2.8	8.4	0.27	47	0.64
30—60	3.5	16.0	0.52	32	0.68	2.4	12.2	0.38	32	0.58
60—90	1.9	9.2	0.39	26	0.63	1.2	6.4	0.22	39	0.65
		1 : 7						1 : 7		
0—30	7.1	49.0	0.82	26	0.52	2.2	9.4	0.32	43	0.69
30—60	2.8	17.2	0.55	29	0.62	1.5	12.0	0.39	31	0.56
60—90	1.3	9.7	0.43	24	0.58	1.0	7.3	0.25	37	0.66
		1 : 10						1 : 10		
0—30	5.4	43.9	0.82	23	0.46	1.7	11.3	0.36	42	0.57
30—60	2.0	18.3	0.59	27	0.57	1.4	14.1	0.44	23	0.48
60—90	1.1	11.1	0.49	22	0.54	0.8	8.7	0.31	34	0.67

SSF_o = SSF at zero amount of water.

The above relationship helps to estimate the soluble sodium fraction in a dry soil. The SSF_o values calculated from the limited data are given in Table III. Similar results were rcported by Redly (1977).

TABLE III. SSF at zero moisture

Soil and depth (cm)	SSFo (intercept)
NIRMANVI	
0—30	0.742
30—60	0.576
60—90	0.505
MADARKHANDI	
0—30	0.695
30—60	0.500
60—90	0.410
SUREBAN	
0—30	0.765
30—60	0.410
60—90	0.210
KATKOL	
0—30	—
30—60	0.235
60—90	0.115

The effect of dilution on ESP dilution/ESP original ratio is presented in Figure 2. It may be seen that the above ratio generally decreased on dilution as a consequence of the decrease in ESP. A greater decrease in the ratio was noticed in the surface soil compared to the lower layers. This suggests the relatively easier replacement of exchangeable sodium from the surface layers. This has an important practical implication. In the reclamation of sodic soils gypsum is usually the amendment used The composition of the soil solutior passing through the soil to the lowe layers, to which gyspum has been addec changes qualitatively. It is enriched ir sodium due to the release from the exchangeable position by calcium in the added gypsum. This fact coupled with the difficulty of replacement of sodium in the subsoil calls for a proper appreciation of this factor. The somewhat anomalous behaviour of Nirmanvi soil may be explained by the fact that in this soil the ESP values have not decreased with depth as in other cases. Secondlv, the soil has very low amounts of water soluble calcium and magnesium to cause replacement of sodium from exchangeable sites.

In studies on $Na^{+}-(Ca^{++}+Mg^{++})$ exchange equilibria under submerged soil conditions Pasricha and Ponnamperuma (1978) reported relatively higher amounts of Na in the soil solution at an equivalent exchangeable Na level, which would result in an increased leachability of Na. They pointed out that this effect would not be detected by extraction with a salt solution or from a saturated paste as used in routine analysis. Mashhady and Rowell (1978) found on dilution of mixed Na-clay suspension desorption of Na. They noticed that the desorption of Na was less in vermiculite compared to montmorillonite.

Some of the significant chemical effects of increase in soil to water ratio which accelerates the reclamation of salt affected soils are : dilution of the salt concentration in the liquid phase which enhances the operation of ratio law, solubility of sparingly soluble salts like Gypsum and Calcium carbonate and changes in the equilibria between exchangeable and water soluble cations.

The use of different soil to water ratios depends on the objective of the investigation. If we have to know the approximate concentration and composition of the soil solution for instance in the investigation of plant physiological problems, a narrow soil to water ratio has to be used. If the total soluble salt content in salt affected soils is to be investigated in order to fully characterise such soil bodies the data of higher soil to water ratios are found to be quite useful.

REFERENCES

LEVY, R. and S. FEIGENBAUM. 1977. Effect of dilution on soluble and exchangeable sodium in soils differing in mineralogy. Geoderma, 18 : 193-205

MASHHADY, A. S. and D. L. ROWELL. 1978. Soil alkalinity. I Equilibria and alkalinity development. *J. Soil Sci.*, 29 : 65-75

PASRICHA, N. S. and F. N. PONNAMPERUMA. 1972. Na-(Ca Mg) exchange equilibria under sumerged conditions. *Soil Sci.*, 123: 220-23.

REDLY, M. 1977. Modern methods for the determination of total concentration and ionic composition of the water soluble salt content of soils. Indo-Hungararian Seminar on Management of Salt A.fected Soils. Feb. 7-12, 1977. Central Soil salinity Research Institute, Karnal, Haryana.