Resalinization and low productivity of recently reclaimed salt – affected soils

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Abstract
The objective of this investigation is to find out the reason/s of resalinization of recently reclaimed salt-affected soils. Columns of saline-sodic soils were subjected to leaching by maintaining 10 cm deep layer of water on the soil surface. The leaching process was terminated when electrical conductivity (EC) of the effluent dropped just below 4 dS/m. It was found that 40 % of the total sodium initially present in these soils, remained after the termination of leaching process. This high level of sodium in soil was considered the main reason for resalinization of reclaimed soils in Iraq at which EC of the drain water was used to determine extent of reclamation process. Resalinzation process was attributed to the process of equilibration between solid and solution phases of soil. Accordingly total sodium in soil rather than EC of the effluent (EC of the drain water) is suggested as the major parameter to be considered for determining the reclamation boundary, rather than EC of the drainage water of the field under consideration.

Key Words
Leaching, effluent, total sodium, electrical conductivity, nutrient loss, sodic soil.

Introduction

Reclamation of salt –affected soils consists of salt removal process and lowering salty water table (Balba 1972). It is well known that most reclaimed soils in Iraq are resalinized again in relatively short period of time after cropping. Resalinization process was thought as a consequence of defect in water and salt balance or due to negligence in maintaining active drainage system (Alzubaidi 1989). Others had attributed the problem of resalinization to bad management of farmers (Reports of State Organization of Soil and Reclamation). The majority of salt-affected soils in Iraq are saline – sodic soils which contain high amounts of sodium (Na) along soil profile (Muhawish 1995). Previously, investigators used disturbed soil columns to evaluate leaching process in term of salt movement and distribution along soil profile. Electrical conductivity or chloride ion was used as the index for salt movement and behavior during leaching. Accordingly, quantity of sodium salts remained in soil after the termination of leaching process is completely overlooked in previous studies. Therefore, in this study total sodium content will be used as an indicator for determining the extent and completion of reclamation process. Na displacement in soils differed in salt content, chemical composition and sodium adsorption ratio will be studied as well. These data will be used to find out the reason/s of resalinization of recently reclaimed salt-affected soils in Iraq which is the main objective of this study.

Materials and methods

Two most common salt-affected soils locally named as Shura and Sabakh were used in this study. Shura soil is characterizes by white salt crust on the surface. Sabakh soil on the other hand, is characterizes by accumulation of deliquescent salts on the surface. Soils are classified as Typic Torrifluvent. Samples of both soils were collected from Salman project 20km south of Baghdad. Samples were collected along soil profile starting from the surface down to 80 cm, including the following layers 0-10, 10-20, 20-30, 30-60, and 60-80 cm. Some of soil properties are shown in Table 1. The soil samples were transferred in the same sequence as in field into galvanized iron columns of 100 cm length and 30cm diameter. Soil columns were subjected to conventional leaching under constant water head (10 cm depth) using water collected from Tigris river (EC=0.57 dS/m, pH =7.0).

Leaching process continued until the EC of percolated water dropped below 4 dS/m. Effluent of each column was collected throughout leaching periods to measure pH, EC, and soluble ions. Soil samples along soil columns were obtained by a lord sampler after termination of leaching process to determine electrical conductivity (EC), pH, and sodium adsorption ratio (SAR). All measurements were conducted according to standard methods outlined by Page (1982).

Results and discussion

Table 1 indicates some properties of Shura and Sabakh soil. It is obvious that most total soluble ions exist in the upper 30 cm of both soils, which exceeded 50% of total soluble ions in soil columns. Maximum amount of soluble sodium was recorded in top layer and reduced with depth in both soils which is in agreement with numerous studies (Black 1973). Soluble sodium in different soil layers ranged from 84 to 440 mmol/L and from 207 to 682 mmol/L in Shura and Sabakh soil, respectively. Leaching curve shown in Figure 1 indicate that leaching water equivalent to less than half pore volume was enough to remove most soluble salts from soil columns within approximately ten days of leaching. Data (Table 2) shows tremendous decline in sodium adsorption ratio (SAR) in both soils which may indicate that sodium hazard was markedly eliminated. Soil analysis (Table 3), however showed that high amount of sodium still existed in soil columns even the EC of percolated water dropped below 4 dS/m. Percent of total sodium not removed from soil columns throughout leaching process ranged from 25% to 53%, and from 20 to 46 for Shura and Sabakh soil, respectively. This may indicate that resalinization of reclaimed soils is imminent due to this high sodium content left in the soil.

The relatively high amount of Na remained after reclamation is in fact a significant factor in resalinization through equilibrium process between solid and liquid phases of soil especially under dry conditions at which upward movement is much higher than the downward movement. A recent study by Finlayson and Raid (2007) still confirm that resalinization can occur if there is upward movement of salts by capillary action from a high saline water table, and ignoring the soil status after leaching especially Na status. Moreover,

Table 1. Properties of the soils used in the study.

Property	Shura soil			Sabakh soil		
	0-30 cm	30-60 cm	60-80 cm	0-30 cm	30-60 cm	60-80 cm
Sand (g/kg)	124	94	134	120	74	257
Silt (g/kg)	365	474	354	238	350	180
Clay (g/kg)	508	438	512	552	577	563
Texture	Clay	Silty clay	Clay	Clay	Clay	Clay
pH (1:5)	7.25	7.82	7.78	7.05	7.32	7.36
EC1:5 (dS/m)	17.8	6.4	4.3	35	6.4	5.3
$CaCO_3$ (g/kg)	310	340	290	310	310	360
OM (g/kg)	8.6	7.2	6.3	9.5	7.9	7.7
CEC (cmol/kg)	20	21	23	25	23	20
Gypsum(cmol/kg)	0.07	0.03	0.01	0.2	0.05	0.07
Na (mmol/L)	440	66	84	682	231	207
SAR	38	15.4	17.7	51	20	18

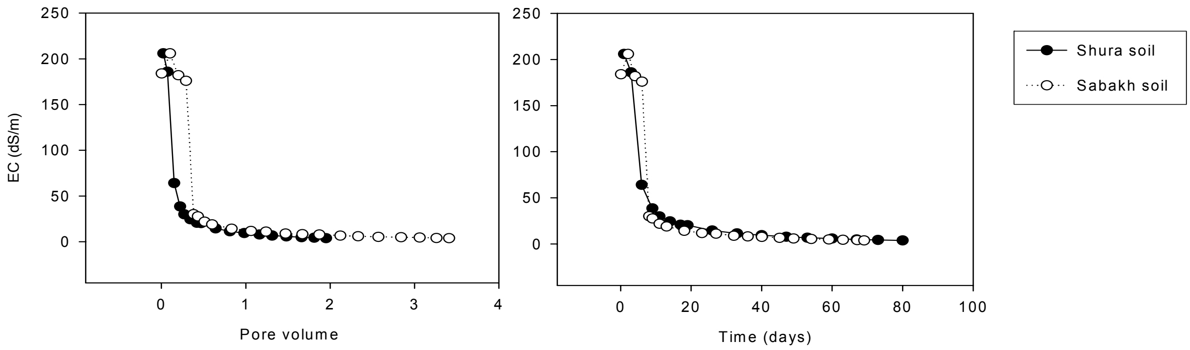

Figure 1. Effect of leaching process and leaching time on electrical conductivity for Shura and Sabakh soils.

Table 2. Effect of leaching process on reclamation parameters of soil on the basis of water extract (1:5).

Soil	Depth (cm)	EC (dS/m)		pH		SAR	
		Before Leaching	After Leacing	Before Leaching	After Leacing	Before Leaching	After Leacing
Shura	0-30	17.8	0.94	7.25	7.73	38	3.1
	30-60	6.4	1.24	7.82	8.10	24	1.7
	60-80	4.3	1.29	7.78	8.22	20	2.8
Sabakh	0-30	35.0	0.68	7.05	7.83	51	2.7
	30-60	6.4	1.5	7.32	7.76	20	2.1
	60-80	5.3	1.54	7.36	8.03	18	4.9

sodium salts are highly soluble in water and a high ratio of sodium in salt affected soils is soluble in soil solution (Black 1973) but this is in no contrast with our results of high sodium remaining along soil profile after leaching because this amount may include sodium salts occluded by soil particles, these soil particles are connected by very small pores and so they are not in direct contact with leaching water moved throughout soil. Sodium remained may also be as sodium salts mixed with another salts of calcium and magnesium which are less soluble, or even sodium salts occluded by clay minerals (Muhawish 1995). Analyzing leachates (Tables 4 and 5) confirm the existence of this amount of sodium ions along soil columns. This method of determination was considered by Panin (1962) to be more accurate to determine leaching efficiency than determination of salt amount in water extract of soil before and after leaching. Results of Table (4) and (5) also indicate that there is a cumulative percentage which valued 65% and 70 % (from initial total sodium content) in leachate of Shura and Sabakh soil respectively. This means that the remaining of total sodium is relatively equal to values obtained by analyzing soil for total Na. This relatively high level of Na remained after reclamation may be one of the main factors led to low productivity of recently reclaimed soils. According to these results total sodium content remained in soil is suggested to to be considered as a reclamation parameter.

Table 3. Effect of leaching process on total Na along columns of Shura and Sabakh soils.

Soil	Depth (cm)	Total Na before leaching (mg/kg)	Total Na after leaching (mg/kg)	Total Na remained as percent of initial (%)
Shura	0-10	19140	4828	25
	10-20	10480	5012	47
	20-30	11980	5725	47
	30-60	10320	4783	46
	60-80	9160	4863	53
Sabakh	0-10	26520	5206	20
	10-20	13560	4572	34
	20-30	15280	5059	33
	30-60	9290	4276	46
	60-80	11320	4968	44

Table 4. Amount of sodium accumulated in leachate of Shura soil

Sample No.	Sample volume (L)	Sodium Conc. In sample (g/L)	Sodium wt. in sample (g)	Percent of total sodium (%)	Cummulative percent (%)
1	7.56	53.61	405.3	49.3	49.3
2	5.17	7.95	41.1	5.0	54.3
3	5.76	4.63	26.67	3.24	57.5
4	4.02	4.6	18.49	2.25	59.79
5	5.42	2.24	12.14	1.48	61.27
6	7.34	1.07	7.85	0.96	62.23
7	27.36	0.85	23.26	2.83	65.06
8	7.92	0.57	4.51	0.55	65.61

Note 1: Percent of total sodium was calculated as follow; $\text{Percent of total sodium in column} = \frac{\text{Wt. of sodium for each sample}}{\text{Total wt. of sodium per column}}$ X 100

Note 2: Total wt. of sodium per column = 821.3 g

Table 5. Amount of sodium accumulated in leachate of Sabakh soil

Sample No.	Sample volume (L)	Sodium Conc. In sample (g/L)	Sodium wt. in sample (g)	Percent of total sodium (%)	Cummulative percent (%)
1	5.2	36.2	188.2	19.8	19.8
2	6.06	42.7	258.8	27.0	46.8
3	5.88	24.3	142.9	15.0	61.8
4	4.87	2.1	10.24	1.0	62.8
5	3.55	2.4	8.52	0.8	63.6
6	21.39	1.89	40.23	4.0	67.6
7	2.7	1.1	2.97	0.3	67.9
8	22.64	0.82	18.56	1.9	69.8
9	17.63	0.47	8.86	0.9	70.7

Note: Percent of total sodium was calculated as for Table 4.

Conclusions

It was concluded that the traditional parameter (EC of the drain water) seems to be inappropriate to determine neither extent of leaching process nor its completion because EC of the leachate never reflect amount of salts remained along soil profile. This study confirmed that approximately 40 % of total sodium initially present in salt-affected soils remained after termination of leaching process according to EC parameter. Therefore, total sodium remained in soil is suggested to be used as an effective index for reclamation process.

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