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Influence of Magnetic Treated Saline Water on Salts Leaching from Salt Affected Soil

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Abstract

To investigate the effect of water magnetic treatment and irrigation water salinity on salt leaching from salt affected soil (40.13dS m^{-1}), a laboratory experiment was conducted using soil columns filled with salt affected soil and leached by using 5 and 10 dS m^{-1} saline water and fresh water (control,1.56 dS m^{-1}). The results showed a remarkable decrease in EC values under all treatments. Concentrations of Na, Ca and Mg decrease with increasing the number of pore volumes. The efficiency of magnetic treatment on leaching soluble salts from soil is higher when using water of low salinity in comparison with water of high salinity level.

Introduction

Water is the most important resources on our planet. World agriculture consumes approximately more than 70% of fresh water with drawn per year [1]. The decrease of water resources is leading towards the use of saline water for irrigation purposes with risk of salt accumulation in root zone [2]. Salt leaching is an important management practice for irrigated agriculture in arid region. The available water for leaching is also limited and contains various dissolved salt in it. The quality of water, especially salinity and sodcity, affects soil structure and permeability [3]. The distribution and removal of water soluble salts mainly depend on soil, salt type, quantity and method of water application [4]. The quality and quantity also influence the composition of soil and drainage water. Irrigation of soils results in release/precipitation of ions from soil, the degree of which depends on soil prosperities, composition and quantity of irrigation water applied [5].

Increasing salinity of irrigation water form 0.58-3.67 dS m^{-1} increased total soil salinity form 1.87-24.83 dS m^{-1} [6]. Thus the salt accumulation in soil was closely related to the salt concentration of irrigation water. The use of irrigation water quality on chemical properties of soil has been studied by [7]. He observed that there was a progressive and significant increase in soil salinity values as the salinity of irrigation water increased.

The water applied should be low in sodium content but must be fairly saline. Recently, magnetizing irrigation water has been introduced as an effective mean for soil desalination. The results of many experiments stated that magnetized water to salty soil breaks down the salt crystals twice as fast as un-magnetized water allowing the salt to be leached from soil [8]. It has been reported by [9] that magnetic treatment of water has three main effects: increasing the leaching excess soluble salts, lowering soil alkalinity and dissolving slightly soluble salts. Magnetic field can enhance the characteristics of water i.e. better salt solubility, kinetic changes in salt crystallization, accelerated coagulation, etc [10]. It has been highlighted that magnetized water can remove 50% to 80% of soil chloride, compared to removal of 30% by normal irrigation water [11].

All the previous studies with magnetic treatment used un-saline irrigation water. The present work aimed to investigate the effect of magnetic water treatment and irrigation water salinity on properties of salt affected soil as a result of repeated leaching.

Materials and methods:

Replicated column experiment was conducted in laboratory at University of Duhok, faculty of agriculture and forestry, involving three types of magnetically treated and non-treated water. Magnetic treatment device with magnetic field of (27.4 mT) was used for magnetization. The study involving three water treatments i.e. well water (W1) as control EC=1.56 dS m^{-1}, saline water (W2) EC=5.31dS m^{-1} and saline water (W3) EC=10.48dS m^{-1}, two magnetize treatments (magnetic and non magnetic water), replicated three times.

Columns of polyvinyl chloride (PVC) (45cm long and 7.5cm diameter) were used, the tops of vertically positioned columns were open and the bottom of each column with a porous base was covered with filter paper. Each column packed uniformly with 1000g of air dried, sieved through 2mm screen soil (40.13dS m^{-1}) collected from Sawadah in Wasit Province-Iraq about 167 km South-East of Baghdad(Lat. 32° 38'33.78" N, Long. 45° 53' 39.96" E, Alt. 16 m (a.s.l)).

Soil sub-samples and water of different salinity (collected from above location) were analyzed for selected properties (Tables 1 and 2).

Table 1. Soil analysis before study

Characteristics	Units	
pH		7.59
EC	**dS m^{-1}**	40.13
Na^{+}	**mmolc L^{-1}**	419.85
K^{+}	**mmolc L^{-1}**	0.96
Ca^{2+}	**mmolc L^{-1}**	32.0
Mg^{2+}	**mmolc L^{-1}**	16.0
Cl^{-}	**mmolc L^{-1}**	96.0
CO_3^{-2}	**mmolc L^{-1}**	0.0
HCO_3^{-}	**mmolc L^{-1}**	10.0
SO_4^{-2}	**mmolc L^{-1}**	348.41
SAR	**(mmolc $L^{-1})^{1/2}$**	102.43
Sand	**g kg^{-1}**	171.5
Silt	**g kg^{-1}**	340
Clay	**g kg^{-1}**	488.5
Soil texture	Clay	

The columns were ponded with 500ml of the above types of water and effluents were collected after each 24 hour. The amount of water moving through the soils was measured as the pore volume of drainage. Six leachates (pour volumes) were collected and analyzed. Un-saline water was used in PV6 for all treatments. Soil analysis was also performed at the end of experiment according to [12].

Table 2.Water analysis before and after magnetization.

Characteristics	Units	Before magnetization			After magnetization		
		W1	W2	W3	W1	W2	W3
pH		7.14	7.35	7.38	6.98	7.47	7.44
EC	**dS m^{-1}**	1.56	5.30	10.48	0.86	5.42	11.21
Na^{+}	**mmolc L^{-1}**	2.10	51.74	84.95	1.49	52.33	86.01
K^{+}	**mmolc L^{-1}**	0.05	0.23	0.45	0.07	0.24	0.45
Ca^{2+}	**mmolc L^{-1}**	3.30	6.20	2.60	2.10	6.33	2.71
Mg^{2+}	**mmolc L^{-1}**	5.90	2.80	3.60	7.40	2.83	3.62
CI^{-}	**mmolc L^{-1}**	0.60	0.70	1.62	0.50	0.70	1.60
CO_3^{-2}	**mmolc L^{-1}**	1.00	0.00	0.00	0.80	0.00	0.00
HCO_3^{-}	**mmolc L^{-1}**	6.00	1.20	1.80	4.00	1.00	1.70
SO_4^{-2}	**mmolc L^{-1}**	3.75	59.07	88.18	5.76	60.03	89.49
SAR	**(mmolc $L^{-1})^{1/2}$**	0.98	24.39	48.25	0.68	24.45	48.35

Result and Discussion:

Experiments were carried out using soil columns packed with highly saline sodic soil of EC=40.13dS $m^{-1}$and ESP=16.13, infiltrated by saline water of EC=5.31 and of EC=10.48 dS m^{-1} to investigate reclamation efficiency of saline water under magnetization treatment. A part from magnetic treatment, electrolysis of saline water can also play an important role to reduce soil salinity [13]. Low quality water can be used at first pore volumes to reduce soil salinity then switched to high quality water at the last pore volume.

Generally higher values of pH in leacheates of W2 and W3 were observed compared to control treatment. Considering ~~the~~ EC values, the results of Figure (1) are interesting in a sense that with the application of pore volumes a noticeable change in EC has been observed under all treatments. The EC results showed a decreasing trend with addition of pore volumes. The EC values in the first leachate for all columns were higher compared with the subsequent leachates, and the values of not magnetized treatment were the highest compared to magnetized and control treatments.

After PV1 and when 5.31 dS m^{-1} saline water was used, changes in EC values (i.e. higher values) caused by application of magnetic field. It has been reported that the possibility of using magnetic water to desalinate the soil is accounted for the enhanced dissolving capacity of the magnetized water [10]. He also suggested that even low magnetic field can decrease the soil EC which is good for the removal of salinity from irrigated land by using magnetic water for irrigation.

It can be seen fromFig.1 that the efficiency of magnetic water on removing soluble salts form soil which received water of high salinity was less than those received water of low salinity. Similar results obtained by [9].

Analysis of leachate, Figure (2) showed that all treatments removed most of the sodium during initial collection, leaving little amount to be displaced and leached in later collections. Similar results obtained by [14]. Among the cations under all water application, sodium was leached in higher quantity as compared to calcium and magnesium.

Concentration of sodium fell sharply with application of water to minimum values of about 45.52 and 55.96 $mmol_c$ L^{-1} for non-magnetized (NT) and magnetized treatment (MT) respectively when 5.31 dS m^{-1} water was used and to 72.4 and 148.59 $mmol_c$ L^{-1} respectively when 10.48 dS m^{-1} saline water was used.

Among different water application, higher quantity of sodium was leached under PV1 when non magnetic water was used even more than control.

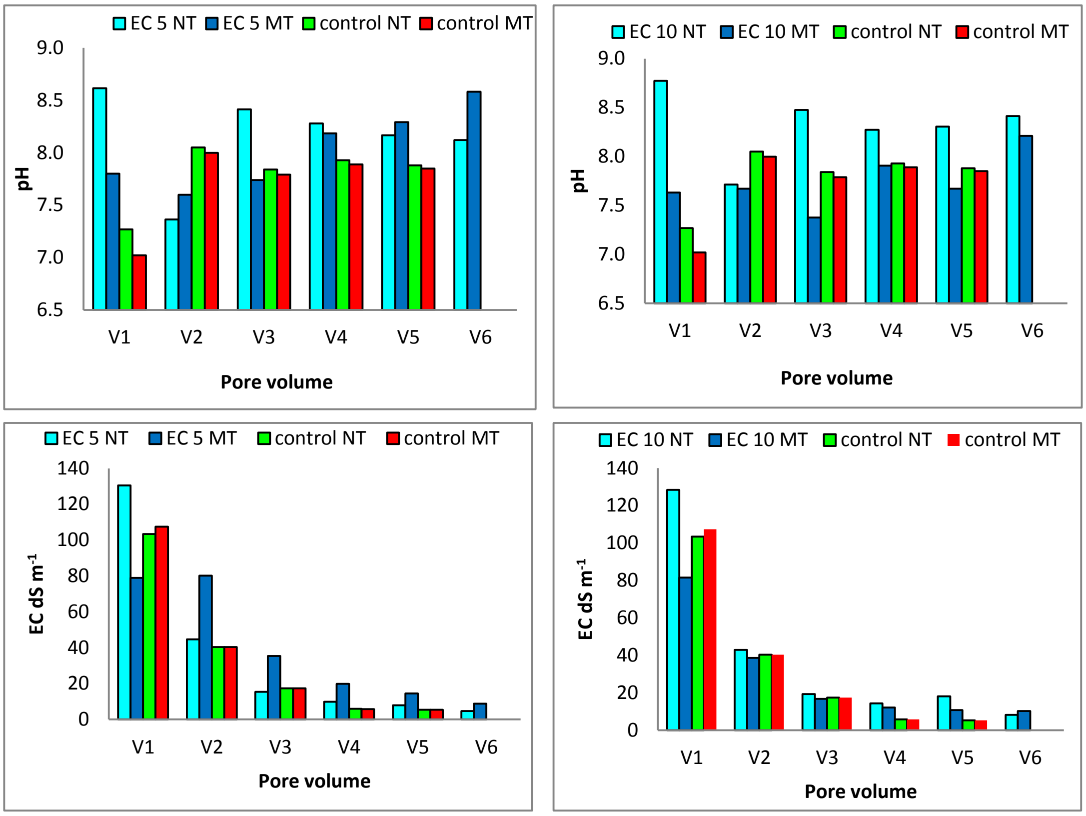

Figure (1): pH and EC of leachates.

The data in Figure (2) showed that less decrease was detected in Ca concentration with application of pore volumes compared to sodium and magnesium. The variation in Ca concentration between all treatments appears to be random and unrelated to the salinity of the water applied or to the magnetization treatment.

Similar trend in Mg concentration of the leachate was obtained compared to that of Na, a sharp decrease with increasing pour volumes. In the last pore volume, concentration of Mg remained below 14 $mmol_c$ $L^{-1}$for all treatments.

The results of chemical analysis carried out on soil samples before and after the leaching process were presented in Table (3). The initial soil pH was 7.59.An increase in soil pH was observed after leaching with W2 and W3 treatments; this may be attributed to leaching of neutral salts that tend to lower the pH by moderating the alkalization reactions [15].

The results also showed that there was a remarkable decrease in soil EC as the values dropped to less than 5 and 7 dS m^{-1} with 5.31 and 10.48 dS m^{-1} saline water respectively. There were no clear differences between magnetized or not magnetized treatment. The results also show that concentration of soluble Na, Ca and Mg decrease by 93.9%, 21.8% and 64.5%respectively with 5.31 dS m^{-1} saline water and by 86.0%, 30.1% and 66.8%, respectively with 10 dS m^{-1} compared to values before leaching when un magnetized water was used and by 92.9%, 27.1%, 67.3% and 86.0%, 29.1% 81.2%, respectively when magnetized water was used.

Compared to control treatment after leaching, Ca concentration was nearly twice that of the control. Slight increase in Mg concentration occurred with exception of magnetic treatment. Sodium increased by 18 and 10 folds for non-magnetic and magnetic treatment respectively when water of 5.31 dS m^{-1} was used, but the increase was higher (43 folds) when 10.48 dS $m^{-1}$was used.

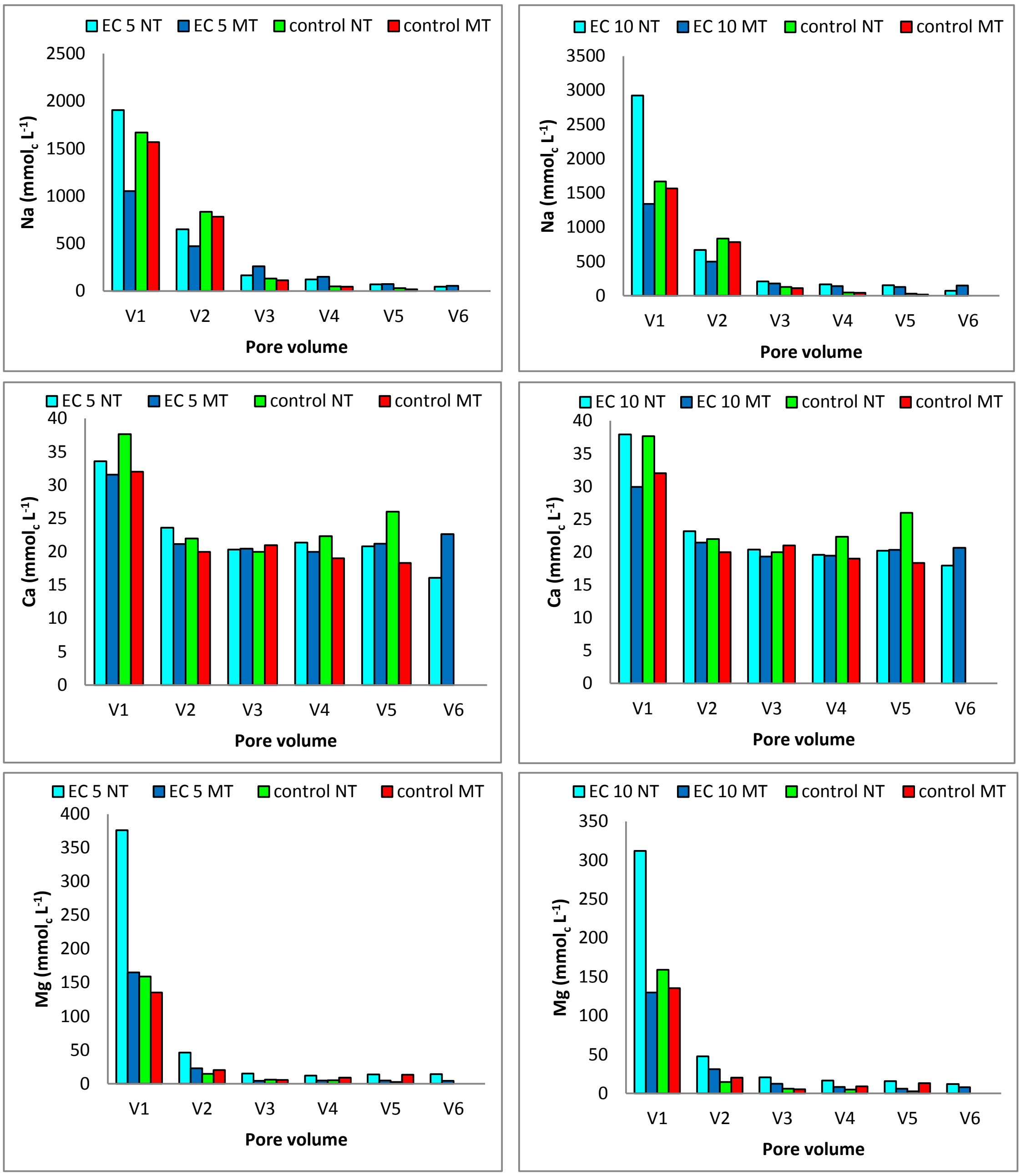

Figure (2): Concentration of cations in leachates.

The decrease in exchangeable Na was positively associated with the number of PVs (Table, 4). Initial soil exchangeable Na dropped from 16.71 to about 3 $mmol_c$ kg^{-1}whenwater of 5.31 dS m^{-1} was used while no change occurred by using water of 10.48 dS m^{-1}, this can be attributed to the higher SAR of 10.48 dS m^{-1} water. Thus the increase in exchangeable Na content of the soil was positively associated with SAR_{iw}; the results are in line with [16].

No differences were observed in Na concentration concerning magnetic treatment. It is remarkable to note that very little increase in exchangeable Na was observed with increasing salinity of irrigation water or with increasing SAR_{iw}.

Using water of 5.31 dS m^{-1} and 10 dS m^{-1} and having 6.2 and 2.6 $mmol_c$ L^{-1} Ca (Table, 2) increased the soil exchangeable Ca from 37.8 to more than 40 $Cmol_c$ kg^{-1},it was much less than the control treatment after leaching. The slight increase explains why high Ca concentration was observed in the leachates. Exchangeable Mg decreased from 47.85 to less than 10 $Cmol_c\ kg^{-1}$for W2 and W3 treatments.

Table (3) Analysis of soluble cations in the soil before and after leaching.

Soil		**pH**	**EC dS m^{-1}**	**Ca**	**Mg**	**Na**
				mmolc L^{-1}		
Before						
C		7.59	38.14	32.0	16.0	419.85
After						
W1	**NT**	7.43	3.29	13.3	4.26	1.35
	MT	7.39	2.99	15.33	1.22	3.16
W2 EC=5.31dS m^{-1}	**NT**	7.82	4.75	25.0	5.67	25.48
	MT	7.75	4.94	23.33	5.33	29.73
W3 EC=10.48dS m^{-1}	**NT**	7.92	6.82	22.33	5.33	58.69
	MT	7.88	6.71	22.67	3.0	58.69

Table (4) Exchangeable cations in the soil before and after leaching.

Soil		**Ca**	**Mg**	**Na**
Before				
T		37.8	47.85	16.71
After ($Cmol_c\ Kg^{-1}$)				
T		**Ca**	**Mg**	**Na**
W1	**NT**	53.68	12.59	3.88
	MT	94.60	12.68	1.45
W2 EC=5.31 dS m^{-1}	**NT**	41.5	8.23	2.78
	MT	43.27	7.47	3.13
W3 EC=10.48 dS m^{-1}	**NT**	46.17	10.27	16.53
	MT	45.33	8.1	16.53

Conclusion:

High saline water 5.31 and 10.48 dS m $^{-1}$ can be used to reduce the initial soil salinity then non saline water can be used for the last two pore volumes to overcome the increasing in EC and ESP of the soil especially in the absence of adequate leaching and drainage. The data also showed that there was no beneficial effect of magnetic treatment on highly saline water in leaching process, but there was some effect when low saline water is used.

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