Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6268

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (2):** 1076-1080 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Effect of Magnetic Treatment on Sodium Adsorption Ratio and Residual Sodium Carbonate

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Received: 19.02.2018 | Revised: 27.03.2018 | Accepted: 4.04.2018

ABSTRACT

An experiment was conducted to study the effect of magnetic treatment on sodium adsorption ratio (SAR) and residual sodium carbonate content (RSC). The SAR values decreased significantly due to magnetic field treatment. However, multiple magnetic exposures (two times and three times passed) resulted in significant increase in SAR. The mean bicarbonate contents decreased significantly due to one-time magnetic treatment. The mean RSC values increased significantly due to one-time magnetic treatment. However, with second magnetic exposure (two times and three times passed), mean RSC value decreased.

Key words: *Sodium adsorption ratio, Residual sodium carbonate, Magnetic treatment, Salinity levels.*

INTRODUCTION

Crop production with poor quality waters, especially loaded with salts has been a challenge all these years. Concerted efforts have been made in this regard and several recommendations have been made for successful crop production using such waters. Use of less expensive and more pro-ecological means such as electrical and magnetic fields have been explored to minimize the effect of salinity on crop. The prospect of using magnetic technologies in agriculture is not a new concept, though not widely accepted by many. Magnetized water is water passed through a magnetic field. Magnetic technology can become a useful tool, as proved by many researchers, to tackle problems related to reduced crop productivity due to use of saline water in agriculture. Magnetized water has been used as an effective means for soil desalinization. Magnetized water applied to salty soil, breaks down the salt crystals and helps in faster leaching of salts. Magnetically treated water has also been found to be effective in preventing and removing scale deposits in irrigation pipes and water containing structures and also increase the levels of CO_2 and H^+ in soils comparable to the addition of fertilizers.

MATERIAL AND METHODS

Laboratory experiment was conducted at Agriculture College, Dharwad to study the effect of magnetized water on irrigation water quality.

Cite this article: Gudigar, A.H., Hebbara M., Manjunath M.V. and Uppin R.M., Effect of Magnetic Treatment on Sodium Adsorption Ratio and Residual Sodium Carbonate, *Int. J. Pure App. Biosci.* **6(2):** 1076-1080 (2018). doi: http://dx.doi.org/10.18782/2320-7051.6268

In this study, irrigation waters of desired salinity were prepared by using natural saline soil. Large quantity of a highly saline soil was collected from farmer's field at Shankratti village, Athani taluk, Belagavi district, Karnataka. The soil was mixed with demineralised water in the ratio of 1:3, stirred vigorously and kept overnight. The supernatant saline water was filtered to remove suspended materials and stored in closed containers. This saline water with 32 dS m^{-1} was diluted appropriately with demineralised water to get desired salinity irrigation waters *viz.*, 4, 8, 12 and 16 dS m^{-1} were used along with demineralised water (0.6 dS m^{-1}) as control (good water).

A permanent magnet with magnetic strength of 1200 gauss was used in this study for magnetizing irrigation waters. A PVC beaker of 2 litre capacity fitted at the top of the unit served as the storage tank for the untreated water. Water from the bottom of this tank enters the magnetic device. The device comprised of a 100 mm pipe section with its internal diameter 20 mm. The device contained two magnets and the arrangement of their north and south poles and the direction of magnetic field generated are shown in Fig. 1. For the magnetic treatment of irrigation water, it was passed through the magnetic treatment device at the flow rate of 12 ml s^{-1}, providing the water a magnetic field exposure of about 6 s.

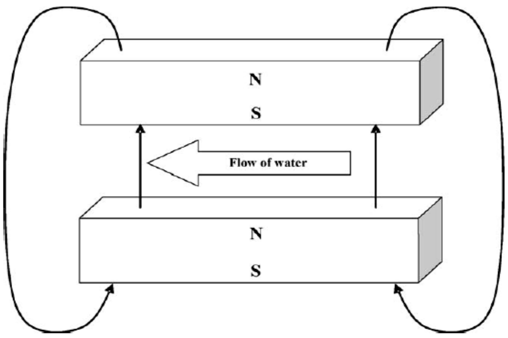

Fig. 1: Schematic diagram of magnetic fields and direction of water flow during the magnetic treatment

Four sets of irrigation waters of good water (0.6 EC), 4, 8, 12 and 16 EC were used. One set of these waters was not magnetically treated (magnetically untreated) while other three sets magnetically treated. Of these, one set was passed once through the magnetic device (one time passed) and characterized. The second set of waters were passed through the magnetic device, collected, again passed (two times passed) and used for characterization. The third set of irrigation waters was first treated as like two times passed but passed once again through the device (three times passed) and characterized. The characterization was done in respect of major irrigation water quality parameters like cations and anions.

Calcium-magnesium and calcium were estimated by versanate titration using Eriochrome Black-T and mureoxide indicators, respectively[1]. Sodium was estimated using flame photometer[1]. Carbonates and bicarbonates of water were estimated by titrating against standard H_2SO_4 using phenolphthalein and methyl orange indicators, respectively[4].

The Sodium adsorption ratio was calculated from the water soluble Na, Ca and Mg (me l^{-1}) by using the following equation[7].

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

The residual sodium carbonate was calculated from the water soluble CO_3, HCO_3, Ca and Mg (me l^{-1}) by using the following equation[7].

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

RESULTS AND DISCUSSION

The magnetic treatments of water significantly influenced calcium, magnesium and sodium content of the irrigation water. Significantly higher calcium content was recorded in magnetic untreated water (16.18 me l^{-1}) under all salinity levels compared to magnetic treated water (15.76 me l^{-1}). Magnetic untreated water also recorded higher magnesium concentration (11.71 me l^{-1}) compared to magnetic treated water (11.45 me l^{-1}). This may be due to the slowing down effect of mineral ions due to crystallization and precipitation processes induced by the magnetic treatment. Similar result was reported by Noran *et al*[6].

Sodium content was also significantly influenced by magnetic treatments. Magnetic untreated water registered higher sodium concentration (62.83 me l^{-1}) which decreased due to magnetic treatment (48.12 me l^{-1}). It is believed that magnetic force breaks hydrogen bonds between water molecules and ions and the ions separated combine with elements and precipitate[6]. Chang and Weng[2] remarked that the enhanced mobility of the ions under a magnetic field may cause serious damage to the hydrogen bond network in the high Na concentration solution.

Consequent to change in calcium, magnesium and sodium contents, the SAR of water was also significantly influenced by magnetic treatments. Irrespective of magnetic treatments and salinity levels of water, the SAR values decreased significantly from 15.68 me l^{-1} (magnetic untreated) to 12.32 me l^{-1} due to magnetic field treatment. However, the SAR values significantly increased due to increasing salinity load in irrigation waters. In both 0.6 and 4 EC water, the SAR remained within the safe limit of 10 but, increased beyond 10 as salinity of water was 8, 12 and 16 dS m^{-1}. This was mainly because of increasingly higher predominance of sodium over calcium plus magnesium in higher salinity waters.

Bicarbonate concentration of the water was significantly influenced by magnetic treatments. Across salinity levels and magnetic treatments, the bicarbonate content decreased significantly due to magnetic treatment. Magnetic untreated water had the bicarbonate content of 1.57 me l^{-1} which decreased due to magnetic treatment (1.44 me l^{-1}). The results are in agreement with the findings of Colic and Morse[3]. Who reported 30 per cent reduction in bicarbonate content in magnetized water compared to normal irrigation water. Madsen[5]. Attributed this reduction to accelerated crystallization of sparingly soluble diamagnetic salts of weak acids such as carbonates due to magnetic field exposure, lowering subsequently the contents of bicarbonates and carbonates in water. However, with increased frequency of magnetization (two times and three times passed), a significant increase in bicarbonate content was observed but still remained significantly lower than the non-magnetized water.

Irrespective of treatments, the RSC values remained negative indicating higher predominance of calcium plus magnesium than bicarbonates. The magnetic treatments of water significantly influenced the RSC of water. The RSC values increased significantly due to magnetic treatment. Irrespective of magnetic treatments and salinity levels of water, magnetic treated water recorded higher RSC value (-25.76 me l^{-1}) compared to magnetic untreated water (-26.32 me l^{-1}). These changes in RSC values are attributed to changes in the concentration of Ca, Mg and bicarbonate contents due to magnetic treatment. It was interesting to note that with increased frequency of magnetization, the RSC values decreased and the three times passed water recorded the lowest RSC of-25.90 me l^{-1} which however, was significantly higher than the RSC of magnetic untreated water.

Table 1: Effect of magnetic treatment on calcium content (me l^{-1}) of irrigation waters

ECiw (dS m^{-1})	Calcium				
	Magnetic untreated	Magnetic treated			Mean
		One time passed	Two times passed	Three times passed	
0.6 (GW)	0.99	0.63	0.62	0.59	**0.61**
4	6.66	6.53	6.60	6.64	**6.59**
8	15.36	14.91	15.00	15.10	**15.00**
12	25.20	24.42	24.74	24.93	**24.70**
16	32.70	31.56	31.89	32.25	**31.90**
Mean	**16.18**	**15.61**	**15.77**	**15.90**	**15.76**

	Magnetic treatment (M)	Salinity levels (S)	M x S
SEm.±	0.03	0.03	0.07
CD (P=0.05)	0.09	0.10	NS

Table 2: Effect of magnetic treatment on magnesium content (me l^{-1}) of irrigation waters

ECiw (dS m^{-1})	Magnesium				
	Magnetic untreated	Magnetic treated			Mean
		One time passed	Two times passed	Three times passed	
0.6 (GW)	0.95	0.84	0.81	0.79	**0.81**
4	5.43	4.89	5.22	5.34	**5.15**
8	11.22	11.07	11.16	11.17	**11.13**
12	17.26	17.01	17.17	17.22	**17.13**
16	23.69	22.71	23.09	23.19	**23.00**
Mean	**11.71**	**11.30**	**11.49**	**11.54**	**11.45**

	Magnetic treatment (M)	Salinity levels (S)	M x S
SEm.±	0.08	0.09	0.18
CD (P=0.05)	0.23	0.26	NS

Table 3: Effect of magnetic treatment on sodium content (me l^{-1}) of irrigation waters

ECiw (dS m^{-1})	Sodium				
	Magnetic untreated	Magnetic treated			Mean
		One time passed	Two times passed	Three times passed	
0.6 (GW)	5.21	4.34	4.34	4.34	**4.34**
4	28.98	18.11	21.73	25.36	**21.73**
8	65.21	43.47	50.72	57.97	**50.72**
12	98.81	65.87	76.86	87.83	**76.85**
16	115.94	72.46	86.95	101.44	**86.95**
Mean	**62.83**	**40.85**	**48.12**	**55.39**	**48.12**

	Magnetic treatment (M)	Salinity levels (S)	M x S
SEm.±	0.02	0.03	0.80
CD (P=0.05)	0.07	0.08	NS

Table 4: Effect of magnetic treatment on SAR (me l^{-1}) of irrigation waters

ECiw (dS m^{-1})	Sodium adsorption ratio				
	Magnetic untreated	Magnetic treated			Mean
		One time passed	Two times passed	Three times passed	
0.6 (GW)	5.31	5.10	5.16	5.22	**5.16**
4	11.82	7.60	8.94	10.39	**8.98**
8	17.91	12.07	14.04	16.01	**14.04**
12	21.48	14.47	16.81	19.13	**16.80**
16	21.87	13.93	16.59	19.28	**16.60**
Mean	**15.68**	**10.63**	**12.31**	**14.01**	**12.32**

	Magnetic treatment (M)	Salinity levels (S)	M x S
SEm.±	0.02	0.02	0.05
CD (P=0.05)	0.06	0.07	NS

Table 5: Effect of magnetic treatment on bicarbonate content (me l^{-1}) of irrigation waters

ECiw (dS m^{-1})	Bicarbonate				
	Magnetic untreated	Magnetic treated			Mean
		One time passed	Two times passed	Three times passed	
0.6 (GW)	1.29	1.23	1.25	1.27	**1.25**
4	1.43	1.32	1.40	1.41	**1.38**
8	1.60	1.37	1.42	1.55	**1.45**
12	1.73	1.43	1.49	1.70	**1.54**
16	1.81	1.47	1.53	1.80	**1.60**
Mean	**1.57**	**1.36**	**1.42**	**1.55**	**1.44**

	Magnetic treatment (M)	Salinity levels (S)	M x S
SEm.±	0.02	0.03	0.05
CD (P=0.05)	0.07	0.08	NS

Table 6: Effect of magnetic treatment on RSC (me l^{-1}) of irrigation waters

ECiw (dS m^{-1})	Residual sodium carbonate				
	Magnetic untreated	Magnetic treated			Mean
		One time passed	Two times passed	Three times passed	
0.6 (GW)	-0.65	-0.24	-0.18	-0.11	**-0.18**
4	-10.66	-10.10	-10.42	-10.57	**-10.36**
8	-24.98	-24.61	-24.74	-24.72	**-24.69**
12	-40.73	-40.00	-40.42	-40.45	**-40.29**
16	-54.58	-52.80	-53.45	-53.64	**-53.30**
Mean	**-26.32**	**-25.55**	**-25.84**	**-25.90**	**-25.76**

	Magnetic treatment (M)	Salinity levels (S)	M x S
SEm.±	0.04	0.05	0.10
CD (P=0.05)	0.12	0.14	NS

CONCLUSION

The SAR values decreased significantly due to magnetic field treatment. The SAR values significantly increased due to increasing salinity load in irrigation waters. However, multiple magnetic exposures (two times and three times passed) resulted in significant increase in SAR. The mean bicarbonate contents decreased significantly due to one-time magnetic treatment. Further, multiple magnetic exposures significantly increased bicarbonate content. The mean RSC values increased significantly due to one-time magnetic treatment. However, with second magnetic exposure (two times and three times passed), mean RSC value decreased.

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