RESEARCH ARTICLE

EFFECT OF GROUND WATER QUALITY ON SOIL SALINITY AND CHEMICAL COMPOSITION OF MUSTARD CROP OF GHARSANA TEHSIL, DISTRICT SRIGANGANAGAR, RAJASTHAN

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Abstract: The survey of ground water quality on soil salinity and chemical composition of mustard crop of Gharsana tehsil, district Sriganganagar, Rajasthan" was undertaken to assess the quality of ground water and its effect on physico-chemical properties of soils and chemical composition of mustard. Forty ground irrigation water samples along with their corresponding forty surface (0-15 cm depths) soil and mustard plant samples were collected from different villages of Gharsana tehsil. The quality of irrigation water were analyzed for physico-chemical characteristics such as pH, EC_{iw}, SAR, RSC and potential salinity and it was found that majority of ground waters of the study area are not suitable for irrigation purposes. The effects of quality of irrigation water on the soil salinity were determined. The results showed that all irrigated fields have high salt concentration as indicated by pH_2, EC_2 and SAR_2 values of soil samples. Saline water increased the soil salt. Thus, the salts accumulation in soil was closely related to the salt concentration of irrigation water, and there was a progressive and significant increase in soil salinity values as the potential salinity of irrigation water increases. Use of high ECiw (8.60 dS/m), pH (9.69), SARiw (18.61), RSCiw (12.30 me/L) and potential salinity (71.61 me/L) of ground water decreased the per cent K^+ and Mg^{+2} content in mustard plant leaves due to relative dominance of Na^+ ion resulting increased Na^+ and Ca^{+2} content.

Keywords: Ground water quality, Salinity, Correlation, Mustard

INTRODUCTION

Profitable agriculture in arid and semi-arid regions is mainly dependent on the fair availability of good quality irrigation water. Fresh surface water supplies in these areas are gradually becoming short to meet the crop water requirement. To augment the inadequate water supplies the use of poor quality ground water is imperative. Unfortunately, the major portion of this water (75 per cent) is unfit for irrigation due to variable amounts of sodium and bicarbonate ions [Malik *et al.* 1984]. Water used for irrigation can also vary greatly in quality depending upon the type and quantity of dissolved salts. In irrigated agriculture, the hazard of salt water is a constant threat. Poor-quality irrigation water becomes more concern as the climate changes from humid to arid conditions. Salts are originated from dissolution or weathering of rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These substances are carried with the water to wherever it is used (UCCC, 1974). Continuous and prolong use of poor quality groundwater could induce salination/sodication of soils and greatly hamper the growth of most of the agronomic crops [Singh *et al.* 1992]. However, the quality of the irrigation water applied will also affect the soil chemical properties which influence soil dispersion and aggregate breakdown, surface sealing and crust formation (Shainberg and Letey, 1984). High residual sodium carbonate (RSC) irrigation water is characterized by sodium carbonate as a predominant salt. The prolonged use of such water immobilizes soluble Ca and Mg in the soil by precipitating them as carbonates. Consequently, increases the concentration of Na^+ in the soil solution and exchangeable complex and leads to development of sodic conditions. The use of sodic water for irrigation adversely affects productivity of soil by influencing the uptake of nutrients (Chauhan *et al.* 1988). The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (Ayers and Westcot, 1985; Rowe *et al.*, 1995). Specific ion effect may also deteriorate metabolic activities in the plants and ultimately the plants may die. Actually, plants take up excessive amounts of Na^+ at the cost of K^+ and Ca^{2+} in a saline environment (Kuiper, 1989). An attempt has been made to study the effect of ground water quality on soil salinity and chemical composition of mustard crop of Gharsana tehsil, district Sriganganagar, Rajasthan. Gharsana tehsil is located in north-west part of the Sriganganagar district (Rajasthan) and situated between 29°02' north latitude and 73°05' east longitude and elevation of 156 m from mean sea level. It is a part of semi-arid belt of Rajasthan having geographical area of 1589.33 km^2. It is surrounded by the tehsil Anupgarh in north and Chhatargarh, pugal and khajuwala tehsil of Bikaner district in south east and western border touches Fort Abbas tehsil of Bahawalnagar district of Pakistani Punjab. The study area lies in the agroclimatic zone-Ib. The climate of the area is typically semi-arid.

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Rainfall and temperatures are the two main elements of the climate. The rainfall is seasonal and not properly distributed and it varies between 100 to 350 mm annually which is mostly received during the months of July to September. In summer maximum temperature ranges between 37^0C to 49^0C and in winter the minimum temperature varies from 1^0C to 10^0C and sometimes it falls below 0^0C. Weather hazards are also not uncommon in this region; like storms during summers, fog during winters and nights are frosty.

MATERIAL AND METHOD

Forty ground water samples were collected from the tube wells which were used for irrigating the field crops. Water samples were taken from the pumps and collected in clean and ringed plastic bottles of 150 ml capacity with all necessary precautions. In the laboratory, water samples were analyzed for EC, pH, major cations and anions such as Na^+, Ca^{++}, Mg^{++}, K^+, Cl^-, HCO_3^-, $CO_3^{--}$and SO_4^{--}. The value of SAR, RSC and potential salinity were also calculated. Along with each water sample, representative and composite soil samples irrigated with tube well waters were collected from surface layers 0-15 cm soil depths, mixed thoroughly and analyzed for EC_2, pH_2 and SAR_2. All the parameters were analyzed by using standard methods outlined by Richards (1954). Fourty samples of mustard leaves at flowering stage were collected from the same sites of water and soil sampling and analyzed for Ca^{2+}, Mg^{2+}, Na^+ and K^+ as per procedure described by Richards (1954) and Bhargava and Raghupati (1993).

RESULT AND DISCUSSION

Water and soil characterization

pH:-A perusal of data in **table 1** revealed that the pH of ground water of Gharsana tehsil in Sriganganagar district of Rajasthan under mustard crop varied from 7.68 to 9.69 with the mean value of 8.92 and the pH_2 of soils ranged between 7.70 to 9.87 with mean value 9.01.. The pH of ground irrigation water under mustard cultivation had shown significant and negative correlation with EC_{iw} (r = -0.378**) of irrigation water and EC_2 (r= -0.446**) of soil showing significant and positive correlation with SAR_2 (r= 0.255**) of soil and pH_2 of soil positively correlated with EC_{iw} (r = 0.014) and pH (r= 0.232**), RSC (r = 0.182*), of irrigation water. Further pH_2 of soil significantly and positively correlated with SAR (r= 0.457**) of irrigation water and SAR_2 (r = 0.407**) whereas, negative and significantly correlated with EC_2 (r= -0.214**) of soil (Table 2). Similar findings were also reported by Ram (2003) and Sharma (2005).

EC:-The data presented in table 1 indicated that the electrical conductivity of ground irrigation water varied between 1.11 to 8.60with mean value of 3.58 dS m^{-1} and the EC_2 of soils varied from 1.0 to 5.82 with mean value 1.82 dS m^{-1}. EC of ground irrigation showed significant positive correlation with potential salinity (r = 0.988**) and EC_2 (r= 0.344**) of soil. It also shows positive correlation with, pH_2 (r = 0.014) and negative correlation with SAR_2 (r = -0.048) of soil. The EC_2 of soil significantly and positively correlated with EC_{iw} and negatively correlated with pH of irrigation water (Table 2). Similar results have been reported by Mascellis *et al.* (2011) and Cucci *et al.* (2013).

SAR:-The data presented in table 1 indicated that the SAR values of ground irrigation ranges between 4.21 to 18.61 and the SAR_2 values of soils varied between 0.20 to 4.50.The SAR of irrigation water under mustard cultivation exhibited SAR of irrigation water showed significant and positive correlations with EC_{iw} (0.355**), pH (r = 0.417**), RSC (r = 0.304**), potential salinity (0.309**) of irrigation water and pH_2 (0.457**), SAR_2 (0.233**) of soil. It also shows non-significant and negative correlation with EC_2 (r = -0.135) and organic carbon (r = -0.124) content of soil. The SAR_2 of soils also observed positive and significant correlation with SAR (r = 0.233**), pH (r = 0.255**), RSC (r = 0.323**) of irrigation water and pH_2 (r = 0.407**) of soil (Table 2). The SAR values increased with an increase in SAR, RSC, pH of irrigation water and pH_2 of soils might be due to dominance of soluble Na^+ over Ca^{2+} and Mg^{2+} contents. Similar results were also reported by Ram (2003), Sharma (2005), Holanda Filho *et al. (*2011) and Cucci *et al.* (2013).

RSC:-The RSC indicates the excess of carbonate and bicarbonates over calcium and magnesium in ground irrigation water. The data presented in table 1 revealed that RSC values of ground irrigation water varied from nil to 12.30 me L^{-1}. The RSC of ground water showed significantly and positively correlation with SAR (r = 0.304**) and pH (r = 0.654**) of irrigation water. Further, RSC of irrigation had shown positive correlation with pH_2(r = 0.182*), SAR_2 (r = 0.323**) and significantly negative correlated with EC_2(r = -0.304**) of soil (Table 2). Thus, high RSC water reduces the soil salinity due to precipitation of Ca^{2+} and Mg^{2+} ions into their carbonate and bicarbonates formed in soil solution. Singh and Singh (1997), Oswal (1999) and Ram (2003) have also reported the similar results.

Potential salinity:-Potential salinity = $Cl^- + 12\ SO_4^{2-}$, all ions are expressed as me L^{-1} Doneen (1963). The chloride salts are more harmful than sulphates. This is because when both the ions occur in high concentrations, only half of the sulphate ions contribute to salinity due to the fact that approximately half of the sulphates get pricipited as $CaSO_4$ while the other half remains in soluble form as Na-$MgSO_4$ in the soil (Gupta 1979). The data presented in table 1 indicated that potential salinity values of ground irrigation water under mustard

cultivation varied from 2.01 to 71.61 with a mean value of 25.51 me L^{-1}.

Plant characterization

Na^+:-Data presented in table 3 indicates that the Na^+ content in mustard leaves ranged from 0.70 to 4.40 with an average value of 1.34 per cent. Na^+ content in mustard leaves had shown significant and positive correlation with EC_{iw} (r= 0.767**), SAR (r= 0.514**) and potential salinity (r= 0.757**) of ground irrigation water (Table 4). These results are supported by the findings of Chhipa and Lal (1985), Ragab *et al.(*2008), Shamsi and Kobraee (2013) and Yousufinia *et al*.(2013).

K^+ :-The data presented in table 3 revealed that K^+ content in mustard leaves varied from 4.00 to 4.99 with an average value of 4.71 per cent. K^+ content in the leaves of mustard plant had shown significant and negative correlation with EC_{iw} (r= -0.974**), SAR (r= -0.715**), potential salinity (r= -0.967**) of ground irrigation water (Table 4). These results get support from the findings of Balki and Padole (1982), Chhipa and Lal (1985) and Pathan (1987), Shamsi and Kobraee (2013).

Ca^{+2}:- It is evident from the data presented in table 3 that the Ca^{2+} content of mustard leaves ranged from 0.06 to 0.90 with an average value of 0.72 per cent. Ca^{+2} content in mustard leaves showed significant and positive correlation with EC_{iw} (r= 0.980**), SAR (r= 0.649**), potential salinity (r= 0.973**) of ground irrigation water (Table 4). These results are in conformity with the findings of Chhipa and Lal (1985), Jat (1986), Khandelwal (1986) and Kumawat (1989).

Table 1. Chemical characteristics Ground water and soils of Gharsana tehsil in Sriganganagar district under mustard cultivation.

Sample Code No.	Ground water					Soil			Plant			
	pH	EC_{iw} (dSm^{-1})	RSC_{iw} (me L^-)	SAR_{iw}	Potential salinity (meL^{-1})	pH_2	EC_2 (dSm^{-1})	SAR_2	Na^+ (%)	K^+ (%)	Ca^{+2} (%)	Mg^{+2} (%)
S_1	8.93	2.47	0.00	9.59	19.01	9.22	1.38	2.45	0.95	4.98	0.68	0.60
S_2	9.05	2.12	2.40	9.30	13.26	8.74	1.54	1.45	0.80	4.80	0.65	0.70
S_3	8.23	6.80	0.00	8.50	58.26	8.44	3.84	3.80	2.00	4.35	0.82	0.30
S_4	8.92	1.68	0.00	6.97	12.31	9.02	1.36	3.20	0.75	4.90	0.65	0.68
S_5	9.24	2.31	3.40	9.98	13.76	8.69	1.39	3.30	0.85	4.96	0.68	0.64
S_6	9.22	3.87	4.20	9.66	20.86	9.14	1.15	2.40	1.30	4.75	0.72	0.62
S_7	9.08	2.54	4.80	9.73	13.51	8.62	1.33	1.70	1.50	4.85	0.7	0.60
S_8	9.34	6.94	0.00	11.25	58.61	8.93	1.35	1.80	1.95	4.25	0.83	0.29
S_9	8.94	8.20	0.00	10.04	63.77	8.89	3.40	2.94	2.00	4.00	0.87	0.25
S_{10}	7.90	4.42	0.00	6.90	35.51	7.94	3.12	1.56	1.40	4.50	0.75	0.40
S_{11}	8.22	3.65	0.00	4.38	29.54	8.42	2.58	1.20	1.50	4.80	0.7	0.42
S_{12}	7.68	4.48	0.00	4.32	38.20	8.07	2.65	1.50	1.45	4.60	0.78	0.45
S_{13}	9.00	1.12	0.60	5.51	6.61	8.63	1.78	1.00	0.80	4.98	0.65	0.38
S_{14}	8.13	4.50	0.00	8.80	31.64	9.65	1.30	3.23	1.45	4.70	0.75	0.70
S_{15}	8.35	4.25	0.00	8.60	29.74	9.52	1.26	3.00	1.42	4.50	0.74	0.40
S_{16}	9.04	1.35	2.30	7.51	7.56	9.59	1.32	3.30	0.79	4.99	0.66	0.63
S_{17}	9.62	3.91	5.26	17.25	27.05	9.44	1.14	3.60	1.30	4.75	0.73	0.43
S_{18}	9.05	4.72	2.50	17.25	34.71	9.52	1.38	3.00	4.40	4.50	0.77	0.38
S_{19}	9.06	1.60	2.41	4.21	5.96	9.23	1.22	2.80	0.78	4.95	0.65	0.65
S_{20}	9.66	1.73	9.10	8.57	3.37	9.54	1.48	4.00	0.85	4.97	0.66	0.64
S_{21}	8.79	5.70	0.00	12.82	48.61	9.38	1.34	3.70	1.86	4.39	0.8	0.35
S_{22}	9.49	2.72	4.90	9.90	14.26	9.00	1.20	2.90	1.00	4.80	0.68	0.60
S_{23}	8.72	6.94	0.00	11.21	59.00	8.94	2.65	2.40	2.25	4.20	0.84	0.30
S_{24}	9.20	1.82	6.76	8.79	6.66	9.34	1.11	2.80	0.75	4.97	0.66	0.70
S_{25}	9.52	1.56	12.30	17.93	2.01	9.49	1.24	4.00	0.70	4.98	0.65	0.72
S_{26}	9.69	2.35	11.21	18.45	9.84	9.22	1.18	4.20	0.86	4.90	0.69	0.62
S_{27}	9.30	1.17	2.80	8.18	6.44	8.60	1.73	0.20	0.75	4.97	0.64	0.75
S_{28}	8.90	1.65	6.38	7.35	7.46	9.16	1.25	1.80	0.77	4.96	0.66	0.70
S_{29}	8.33	5.68	0.00	12.45	47.49	9.49	2.45	0.50	1.80	4.42	0.82	0.34
S_{30}	8.44	4.64	0.00	9.59	37.14	9.22	1.14	3.40	1.55	4.52	0.77	0.40
S_{31}	9.03	7.15	0.00	18.61	59.25	9.70	3.85	2.00	2.50	4.22	0.83	0.32
S_{32}	9.39	1.11	2.20	12.34	7.54	9.09	1.30	2.80	0.70	4.99	0.6	0.75
S_{33}	9.29	1.84	7.32	10.32	7.14	9.10	1.16	2.90	0.75	4.96	0.65	0.72
S_{34}	8.62	4.98	0.00	9.99	41.41	8.57	2.45	0.50	1.48	4.60	0.8	0.36

S_{35}	9.20	1.97	4.47	6.96	8.26	7.70	1.00	2.98	0.82	4.90	0.67	0.64
S_{36}	8.93	8.60	0.00	15.65	71.61	8.92	1.81	3.60	2.80	4.10	0.9	0.20
S_{37}	9.04	3.69	0.00	8.90	25.19	8.73	1.64	3.00	1.32	4.80	0.7	0.55
S_{38}	8.43	3.54	0.00	8.53	25.37	9.87	1.36	4.50	1.30	4.75	0.69	0.58
S_{39}	9.37	2.18	2.00	6.00	9.72	8.68	1.28	3.50	0.80	4.85	0.65	0.50
S_{40}	8.65	1.16	3.90	4.93	3.00	9.05	5.82	4.20	0.78	4.98	0.64	0.70
MEAN	**8.92**	**3.58**	**2.53**	**9.93**	**25.51**	**9.01**	**1.82**	**2.68**	**1.34**	**4.71**	**0.72**	**0.52**
MAXI.	9.69	8.60	12.30	18.61	71.61	9.87	5.82	4.50	4.40	4.99	0.90	0.75
MIN.	7.68	1.11	0.00	4.21	2.01	7.70	1.00	0.20	0.70	4.00	0.60	0.20

Table 2. Correlation between chemical characteristics of ground water and soil

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		EC_{iw}	**pH**	**RSC_{iw}**	**SAR_{iw}**	**Potential salinity**	**EC_2**	**pH_2**	**SAR_2**
1	**EC_{iw}**	1.000	-0.378**	-0.538**	0.355**	0.988**	0.344**	0.014	-0.048
2	**pH**		1.000	0.654**	0.417**	-0.441**	-0.446**	0.232**	0.255**
3	**RSC_{iw}**			1.000	0.304**	-0.621**	-0.304**	0.182*	0.323**
4	**SAR_{iw}**				1.000	0.309**	-0.135	0.457**	0.233**
5	**Potential salinity**					1.000	0.373**	-0.025	-0.113
6	**EC_2**						-0.135	0.074	-0.093
7	**pH_2**						1.000	-0.214**	-0.097
8	**SAR_2**							1.000	0.407**

*indicates significant at 5% level ** indicates significant at 1% level of significance

Table 3. Correlation between chemical characteristics of ground water and mustard plant

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		EC	**pH**	**RSC**	**SAR**	**Potential salinity**	**Na**	**K**	**Ca**	**Mg**
1	**EC**	1.000	-0.378**	-0.538**	0.685**	0.988**	0.767**	-0.974**	0.980**	-0.866**
2	**Ph**		1.000	0.654**	0.058	-0.441**	-0.259**	0.376**	-0.405**	0.370**
3	**RSC**			1.000	-0.150	-0.621**	-0.405**	0.548**	-0.507**	0.577**
4	**SAR**				1.000	0.636**	0.514**	-0.715**	0.649**	-0.520**
5	**Potential salinity**					1.000	0.757**	-0.967**	0.973**	-0.882**
6	**Na**						0.473**	0.046	-0.078	0.007
7	**K**						1.000	-0.765**	0.770**	-0.720**
8	**Ca**							1.000	-0.957**	0.873**
9	**Mg**								1.000	-0.878**

*indicates significant at 5% level ** indicates significant at 1% level of significance

Mg^{+2} :- Data presented in table 3 indicated that Mg^{2+} in mustard leaves varied from 0.20 to 0.75 with an average value 0.52 per cent. Mg^{+2} content in the leaves of mustard plant had shown significant and negative correlation with EC_{iw} (r= -0.866**), SAR (r= -0.520**), potential salinity (r= -0.882**) of ground irrigation water (Table 4). These results are supported by the findings of Lal *et al.* (1980), Somani (1982) and Girdhar and Yadav (1989).

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