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Impact of quality of ground water irrigation on soil health in bilara tehsil of Jodhpur

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Abstract
The present investigation "Impact of quality of ground water irrigation on soil health in Biara tehsil of Jodhpur" was undertaken to assess the quality of ground water from respective irrigated fields were collected. Based on EC, SAR and RSC ground waters were classified into three categories viz: saline (15%), high SAR saline (70%) and marginally alkali (15%) and it was found that majority of ground waters of the studied area are not suitable for irrigation of crops.

Keywords: Saline water, Farmer's field

Introduction

The natural resources of any country are the national treasure and need proper planning to make best of them. Due to the inadequacy of surface water. The ground water is becoming more and more important in India's agriculture and food security in the recent years. It has become the main source of growth in irrigated areas over the past 3 decades, and now it accounts for over 60 percent of the irrigated area in the country. It is estimated that over 70 per cent of India's food grain production comes from irrigated agriculture, in which ground water plays a major role (Gandhi and Namboodiri, 2009) [6]. Over the last two decades, 84 per cent of the total addition to net irrigated area came from ground water, and only 16 per cent from canals (Brisco and Malik 2006) [3]. The estimated total replenishable ground water resource in India is 43.57 million hectare-meters per year. After allowing 14 per cent for domestic, industrial and other uses. The ground water available for irrigation is estimated to be about 86 percent of this i.e. 36.42 million hectare-meters. Out of this the utilizable ground water resources for irrigation is only 32.77 million hectare meters. (Gandhi and Namboodiri, 2009) [6]. Due to over exploitation of ground water, the average water table decline 0.66 per cent per year could reduce India's total food grain production by around 25% or more by 2050 (Gupta and Deshpande, 2004) [9]. India accounts for 2.2 per cent of the global land, 4 percent of the world water resources and 16 per cent of the world population (Ramesh and Elango, 2011) [19]. Apart from water table decline ground water quality is also a major concern in many parts of the country (Ramprakash *et al*. 2013) [20]. The salt content of soil closely related to salt content of irrigation water (Lal and Lal, 1988 and Khandelwal and Lal, 1991) [13, 14] therefore, quality of irrigation water in relation to its impact on soil properties is of interest in arid and semi-arid areas. In Rajasthan, arid and semi-arid tract occupy about three fourth of the state and ground water which is dubious quality is the main source of irrigation in this belt. Presence of dissolved salts in higher proportion is a common feature of ground water in western Rajasthan (Garg, 2011) [7]. In general, the chemical quality of ground water is fresh in the eastern part except in the localized area of Bharatpur district. However, chemical quality in the major parts of western Rajasthan is brackish to saline. The arid districts of western Rajasthan viz., Barmer, Bikaner, Churu, Ganganagar, Hanumangarh, Jaisalmer, Jalore, Jodhpur, Nagaur and Pali have ground waters. Majority of the ground water in the western arid districts have EC upto 10 dSm^{-1} whereas in semi-arid and humid districts waters have EC upto 5 dSm-1 and 2.2 dSm^{-1}, respectively.

A systematic study on quality of water and soil is necessary for better utilization of water and soil resources to tackle water and soil problems. The semi- arid and arid area of Rajasthan necessitates the application of supplemental water for optimizing crop production. Majority of the tube well waters contain high concentration of salts and their continuous use for irrigation adversely affects the crop production and causes soil deterioration.

It is necessary to increase the better crop production in that area. It necessitates continuous monitoring of ground water for assessing the possible damage on salinity and alkalinity induced soil health (Sharma, 2011) [13]. Salinity and sodicity are known to influence physiological, biochemical and morphological changes in plants, which reflect on overall performance of the plant. Generally, these changes due to salinity stress may adversely affect the plant growth and metabolism. However, under such conditions some plant species may thrive and yield better than other species by effectively adjusting or modifying their metabolism. Since, the characterization of soil health parameters is lacking in the study area under the influence of underground irrigation water which is essential for better utilization of soil and irrigation water to obtain satisfactory yield by modifying the cultural practices in accordance with the nature of soil and quality of water.

Materials and Method

The investigation reported here in "Impact of quality of ground water irrigation on soil health in Bilara tehsil of Jodhpur" was undertaken in the year 2016-17. The details of techniques and methodology followed during the course of investigation are presented. The Bilara tehsil is situated in the south-eastern part of the Jodhpur district between latitudes of 26°20'54.243" and 260 25'53.695" N and Longitudes of 73°22'55.33" and 73°53'19.113" E. It occupies an area of 1451.89 sq. km and bounded by Pali district in the east-south and north-west and Nagaur district touches in the north-east. It falls under region 2nd of the agro-ecological map (Hot arid ecoregion with desert and saline soils) and in the IIB zone, named as transitional plain of Luni Basin.

Collection of ground water samples

Georeferenced forty samples of tube well / open well were collected of which the waters are being used for irrigation for about ten years. To get proper samples, pump was kept in operation for half an hour before collecting the sample. The water samples were collected in 40 plastic bottles of 500 ml. capacity with all necessary precautions. The bottles were carefully corked, properly labelled and brought to the laboratory for further analysis work. Details of all the sample sites (viz. Name of village, Name of farmer, Depth of tube well and Year of start of tube well) are presented in (table-1)

Table 1: Details of location of sampling sites

S. No.	Sample code no.	GPS Coordinates		Name of Village	Name of Farmer	Depth of Tube well (ft.)	Year of Start
1	BLw1	N 26014.306	E 073027.269	Sindhi Nagar	Ibrahim Khan	160	2007
2	BLw2	N 26014.359	E 073027.345	Sindhi Nagar	Maku Khan	125	2006
3	BLw3	N 26013.083	E 073027.231	Olvi	Hazi Khan	100	2004
4	BLw4	N 26013.082	E 073027.227	Olvi	Mohan Ram	250	2007
5	BLw5	N 26011.742	E 073037.520	Bhavi	Kunna Ram	200	2000
6	BLw6	N 26011.743	E 073037.652	Bhavi	Laduram	300	2004
7	BLw7	N 26012.095	E 073038.864	Jhurli	Heera Lal	160	2004
8	BLw8	N 26012.121	E 073039.004	Jhurli	Omprakash Ji	300	1996
9	BLw9	N 26011.828	E 073042.482	Bilara Chak-I	Ratan Singh	350	2003
10	BLw10	N 26009.753	E 073042.242	Bilara Chak-II	Shesha Ram	550	2001
11	BLw11	N 26006.731	E 073040.715	Jelwa	Lalu Ram	400	2006
12	BLw12	N 26004.559	E 073040.209	Jaitiwas	Dhan Singh	350	1991
13	BLw13	N 26004.181	E 073040.357	Jaitiwas	Babulal	300	1996
14	BLw14	N 26006.583	E 073040.539	Jelwa	Mishrilal	400	2007
15	BLw15	N 26011.788	E 073043.378	Uchirda	Rakesh	300	2006
16	BLw16	N 26011.741	E 073043.842	Uchirda	Puna Ram	400	2009
17	BLw17	N 26013.470	E 073045.404	Khariya	Dharma Ram	500	2002
18	BLw18	N 26013.469	E 073045.429	Khariya	Rana Ram	525	2006
19	BLw19	N 26014.042	E 073045.341	Udaliyawas	Ramesh	450	2007
20	BLw20	N 26014.531	E 073046.095	Udaliyawas	Gopa Ram	500	2003
21	BLw21	N 26015.996	E 073047.183	Jhak	Bhinja Ram	550	2006
22	BLw22	N 26015.914	E 073047.149	Jhak	Ruparam	400	2000
23	BLw23	N 26015.235	E 073046.068	Kuprawas	Nain Singh	525	2006
24	BLw24	N 26015.328	E 073046.137	Kuprawas	Ramji Lal	500	2005
25	BLw25	N 26015.960	E 073044.982	Kelowna	Siyaram	350	2006
26	BLw26	N 26015.716	E 073044.931	Kalawana	Tulcha Ram	500	2003
27	BLw27	N 26015.933	E 073043.624	Rampuriya	Jagdish	350	2007
28	BLw28	N 26015.827	E 073043.439	Rampuriya	Ashok Kumar	450	2006
29	BLw29	N 26012.390	E 073043.148	Pichiyak	Narayan Lal	450	1996
30	BLw30	N 26012.474	E 073042.976	Pichiyak	Rajendra	500	2009
31	BLw31	N 26013.209	E 073039.794	Birawas	Ananda Ram	300	2008
32	BLw32	N 26013.204	E 073039.148	Birawas	Makhan Lal	450	2001
33	BLw33	N 26013.978	E 073040.105	Birawas	Bhagaram	300	2006
34	BLw34	N 26017.042	E 073037.706	Ghanamagra	Sukhadev	400	1980
35	BLw35	N 26018.740	E 073041.192	Khejarla	Goparam	450	2001
36	BLw36	N 26021.890	E 073045.328	Ransigaon	RamSawarop	500	1993
37	BLw37	N 26022.328	E 073045.701	Ransigaon	Kamal Kishor	450	1991
38	BLw38	N 26025.574	E 073050.140	Patel Nagar	Ramniwash	400	1996
39	BLw39	N 26025.334	E 073050.538	Patel Nagar	Ramaram	475	2001
40	BLw40	N 26025.106	E 073049.819	Patel Nagar	Purka Ram	450	2006

Table 2: Methods used for water analysis

S. No.	Properties	Procedure	Reference
A.	Water Analysis		
1.	pH	Using glass electrode pH meter	USDA Hand book No. 60 Richards (1954)
2.	EC	Using the standard precision conductivity bridge	USDA Hand book No. 60 Richards (1954)
3.	Cation: Ca, Mg	Using Versenate titration method	USDA Hand book No. 60 Richards (1954)
	Na+, K+	Using Flame photometry method	USDA Hand book No. 60 Richards (1954)
4.	Anion-CO_3, HCO_3	Titration with standard H_2SO_4 (Method No.12)	USDA Hand book No.60 Richards(1954)
	Cl	Titration was carried with standard $AgNO_3$ (Method No. 13)	USDA Hand book No.60 Richards(1954)
5.	SO_4	Using method by precipitation as barium sulphate (Method No.14)	USDA Hand book No.60 Richards(1954)
6.	Residual Sodium Carbonate (RSC)	RSC=(CO_3+HCO_3)–(Ca+ Mg)	USDA Hand book No.60 Richards(1954)
7.	Sodium Adsorption Ratio	SAR= (Na@√(Ca+Mg))/2	USDA Hand book No.60 Richards(1954)
8.	Adjusted SAR	Adj. SAR=SAR [(1+8.4-pHc)]	Ayers and Westcot (1976)
9.	Potential salinity	Potential salinity= Cl + ½ SO_4	Doneen (1963)

Results and Discussion

PH and EC

A perusal of data in table-1 revealed that the pH of ground irrigation water of Bilara tehsil of Jodhpur district of Rajasthan varied from 7.33 to 8.42 with the mean value of 7.84. The minimum (7.33) and maximum (8.42) pH value were recorded at BLw36 and BLw35 ground water sample, respectively. These results are in conformity with the findings of Mehta (1970) [15], Deo and Lal (1982) [13], Mali (1985) [14], Khandelwal and Lal (1991) [11], Singh *et al*. (1994) The electrical conductivity of ground irrigation water of studied area ranged between 2.47 to 10.52 with mean value of 5.78 dSm^{-1}.The minimum value of EC was found with BLw4 sample, whereas, maximum with Blw7 ground water samples in table-1. When for longer period high salt concentration water is used as irrigation in the field, increased the salt concentration of irrigated field. These results are confirmed to the findings of Deo and Lal (1982), Mali (1985), Khandelwal and Lal (1991) [11], and Verma *et al*. (2003).

Sodium adsorption ratio (SAR)

The data presented in table-1 indicated that the SAR values of ground irrigation water ranged between 8.22 to 20.68. The minimum (8.22) and maximum (20.68) SAR values were recorded with BLw32and BLw25 ground irrigation water samples, respectively. Increase in SAR value of irrigation waters with the increase in pH and EC of irrigation water used due to the dominance of Na over Ca, Mg soluble ions. Similar type of results were also obtained by Shankarnarayan *et al.* (1965), Puntamkar *et al*. (1967), Paliwal and Maliwal (1971) [16], Sharma and Minhas (1998) [18],.

Residual sodium carbonate (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 4.00 me L-1. The maximum RSC value of 4.00 mel^{-1} was found with BLw3 ground irrigation water sample. Thus, high RSC water reduces the soil salinity due to precipitation of Ca and Mg ions into their carbonate and bicarbonates formed in soil solution. Yadav and Tomar (1982) [31] have also reported that the RSC of ground irrigation water influence positively with pH of soil but negatively to EC of soil. Mehta (1970) [15], Singh *et al.* (1995) [22], Prasad *et al.* (1996) [17], Srinivasrao *et al*. (2009) have also reported the similar results.

Potential salinity

Doneen (1963) introduced the term "Potential salinity" of irrigation water and suggested its determination as shown below: Potential salinity = Cl + 1/2 SO_4, all ions are expressed as mel^{-1} and recommended permissible limits as 5-20, 3-15 and 3-7 mel^{-1}, for soils of good, medium and low permeability, respectively. The chloride salts are more harmful than sulphates. The adverse effect due to salinity of 20 dSm^{-1} caused in the presence of chlorides is the same as that of 40 dSm^{-1} in the presence of 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 precipitated as $CaSO_4$ while the other half remains in soluble form as Na-$MgSO_4$ in the soil (Gupta 1979) [10]. The data presented in table-1indicated that potential salinity values of ground irrigation water were varied from 12.08 to 83.54 with a mean value of 45.78 mel^{-1}. The minimum (12.08) and maximum (83.54) potential salinity (mel^{-1}) values found with BLw4 and BLw7 ground irrigation water sample, respectively. Due to continuous use of irrigation waters having higher concentration of chloride and sulphate salts might have resulted in increased salinity (EC) of irrigated fields. These results in accordance with the findings of Gupta (1979) [9] and Bali *et al.* (2015) [2].

Mg/Ca ratio

In Mg/Ca ratio the effects of excessive magnesium over calcium of the ground water were taken into consideration. The calculated values of Mg/Ca ratio of ground irrigation water varied from 0.80 to 1.45 with a mean value of 1.03. The minimum and maximum value of Mg/Ca ratio were found 0.80 and 1.45 in BLw40 and BLw35 ground irrigation water samples, respectively in table 1. The results of the present investigation are in accordance with the findings of Girdhar and Yadav (1982) [31] and Bali *et al.* (2015) [2].

Adjusted sodium absorption ratio (Adj. SAR)

In Adj. SAR the effects of excessive sodium of high HCO_3 or CO_3 of total salts load of the water were taken into consideration. The calculated values of Adj. SAR of irrigation water varied from 24.10 to 59.96 with a mean value of 36.87. The minimum value of adjusted SAR 24.10 was found with BLw4 water sample and maximum value of Adj. SAR 59.96 was recorded BLw25 ground irrigation water sample in table-1. The accumulations of salts in these soils are more because of high Adj. SAR values. The results of the present investigation are in line with the findings of Paliwal and Maliwal (1971) [16], Sharma and Mondal (1981) [18].

Table 3: Ground water chemical characteristics in Bilara tehsil of Jodhpur

S. No.	Sample code no.	pH	EC (dSm^{-1})	SAR	RSC (mel^{-1})	Potential salinity (mel^{-1})	Mg/Ca Ratio	Adj. SAR
1	BLw1	8.00	3.21	9.77	2.76	18.82	1.38	27.37
2	BLw2	8.03	5.96	17.53	0.97	44.16	0.87	52.58
3	BLw3	8.02	2.55	9.83	4.00	13.63	1.05	26.54
4	BLw4	7.80	2.47	8.61	3.98	12.08	1.01	24.10
5	BLw5	7.80	6.14	13.14	0.00	50.75	1.17	39.42
6	BLw6	7.79	6.30	11.82	0.00	52.00	0.87	35.45
7	BLw7	7.39	10.52	9.39	0.00	83.54	1.02	33.79
8	BLw8	7.77	10.24	9.84	0.00	80.87	1.05	35.43
9	BLw9	7.70	4.29	10.94	0.00	33.32	1.11	30.63
10	BLw10	7.55	6.45	15.54	0.00	54.56	0.85	45.06
11	BLw11	7.86	4.94	14.57	0.00	40.08	1.02	40.80
12	BLw12	7.82	5.92	14.19	0.00	45.65	0.94	44.00
13	BLw13	7.80	5.77	13.81	0.00	48.93	1.19	38.66
14	BLw14	8.02	5.99	17.33	0.00	45.50	1.07	50.25
15	BLw15	7.95	5.12	14.86	0.00	42.37	1.20	41.60
16	BLw16	7.49	6.95	13.46	0.00	58.03	1.11	40.39
17	BLw17	8.19	3.23	9.99	2.35	19.52	1.16	25.99
18	BLw18	7.70	5.21	11.37	0.00	42.89	1.05	32.96
19	BLw19	7.82	6.48	12.33	0.00	52.72	1.21	37.00
20	BLw20	7.70	4.31	9.46	0.00	35.31	0.90	26.48
21	BLw21	8.03	3.86	9.99	2.20	22.86	1.13	30.98
22	BLw22	7.99	3.91	10.66	0.00	28.84	0.89	28.79
23	BLw23	7.95	5.39	13.53	0.00	42.23	0.89	40.60
24	BLw24	7.85	5.45	13.89	0.00	44.38	0.94	40.28
25	BLw25	8.02	6.46	20.68	0.40	50.36	1.08	59.96
26	BLw26	7.79	6.65	15.80	0.00	57.10	0.99	45.83
27	BLw27	7.99	5.19	12.80	0.00	43.28	1.11	35.84
28	BLw28	8.00	4.89	12.61	0.00	36.64	1.08	35.31
29	BLw29	7.77	4.49	12.17	0.00	33.92	1.13	34.08
30	BLw30	7.82	4.64	11.03	0.00	35.41	0.92	31.99
31	BLw31	7.70	8.91	9.50	0.00	77.41	0.91	29.44
32	BLw32	7.39	8.04	8.22	0.00	68.15	0.98	25.47
33	BLw33	7.53	9.09	9.49	0.00	78.67	0.95	29.41
34	BLw34	8.40	4.50	13.69	1.72	34.13	1.15	38.32
35	BLw35	8.42	2.96	8.87	3.97	14.96	1.45	24.83
36	BLw36	7.33	5.30	13.95	0.00	42.27	0.84	39.05
37	BLw37	7.75	6.35	13.48	0.00	53.08	1.11	40.44
38	BLw38	7.78	7.68	14.59	0.00	64.36	0.85	43.78
39	BLw39	7.63	7.66	17.08	0.00	66.00	0.89	49.53
40	BLw40	8.15	7.53	13.72	0.00	62.42	0.80	42.54
Mean		7.84	5.78	12.59	0.56	45.78	1.03	36.87
Maximum		8.42	10.52	20.68	4.00	83.54	1.45	59.96
Minimum		7.33	2.47	8.22	0.00	12.08	0.80	24.10

Soluble cations and anions

A perusal of data mentioned in the table-2 revealed that cations like: Ca, Mg, Na and K of ground irrigation water ranged from 3.36 to 27.40, 3.54 to 28.00, 16.80 to 55.13 and 0.06 to 0.32 mel^{-1}, with a mean value of 9.82, 9.86, 37.66 and 0.16 mel^{-1}, respectively. The minimum values of Ca2+ (3.36 mel^{-1}), Mg (3.54 mel^{-1}) were found with BLw3 and Na (16.80 mel^{-1}) was found with BLw4, whereas K (0.06 mel^{-1}) was found with BLw35 ground irrigation water samples. The maximum values of Ca (27.40 mel^{-1}), Mg (28.00 mel^{-1}), Na (55.13 mel^{-1}) and K (0.32 mel^{-1}) were observed with BLw7, BLw7, BLw39 and BLw34 ground irrigation water samples, respectively. In general, sodium was found dominant cation in these ground irrigation waters followed by Mg, Ca and K. The results of the present investigation are in accordance with the findings of Singh *et al*. (1995) [33] and Lal *et al*. (1998) [13].

The data presented in table-2 revealed that anions like Cl, SO_4, CO_3, and HCO_3 of ground irrigation water varied from 11.25 to 80.15, 0.53 to 8.09, 0.20 to 0.80 and 6.80 to 17.60 mel^{-1}, respectively. The minimum values of Cl (11.25 mel^{-1}), SO_4 (0.53 mel^{-1}) were found with BLw4, BLw15 ground water samples, respectively, whereas CO_3 (0.20 mel^{-1}) and HCO_3 (6.80 mel^{-1}) were found with (BLw20, BLw27, BLw31) and (BLw9, BLw16, BLw18, BLw26, BLw36) ground water samples, respectively. The maximum values of Cl (80.15 mel^{-1}), SO_4 (8.09 mel^{-1}), CO_3 (0.80 mel^{-1}) and HCO_3 (17.60 mel^{-1}) were recorded with BLw7, (BLw23, BLw34), BLw33 and BLw7 ground water samples, respectively. In general chloride was found dominant anion in these irrigation water samples followed by HCO_3, SO_4 and CO_3. Similar results were also reported by Singh *et al*. (1995) [35], Lal *et al*. (1998) [13] and Shahid *et al*. (2008) [22].

Table 4: Ionic compositions of groundwater samples of Bilara tehsil

S. No.	Sample code no.	Ionic composition (mel^{-1})							
		Cations				Anions			
		Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4
1	BLw1	21.92	0.08	4.22	5.84	0.40	12.42	18.40	0.84
2	BLw2	45.75	0.18	7.29	6.34	0.50	14.10	43.37	1.58
3	BLw3	18.26	0.10	3.36	3.54	0.40	10.50	12.90	1.46
4	BLw4	16.80	0.08	3.80	3.82	0.40	11.20	11.25	1.65
5	BLw5	41.36	0.25	9.14	10.68	0.60	9.69	50.36	0.78
6	BLw6	39.90	0.18	12.20	10.60	0.40	9.60	51.11	1.77
7	BLw7	49.40	0.23	27.40	28.00	0.50	17.60	80.15	6.78
8	BLw8	49.80	0.24	25.00	26.20	0.40	16.20	77.10	7.54
9	BLw9	28.63	0.11	6.50	7.20	0.20	8.40	32.80	1.04
10	BLw10	46.35	0.15	9.60	8.20	0.40	8.70	53.91	1.29
11	BLw11	36.50	0.15	6.20	6.35	0.40	8.00	39.35	1.45
12	BLw12	41.74	0.16	8.90	8.40	0.60	12.40	45.10	1.10
13	BLw13	40.37	0.15	7.80	9.30	0.40	7.20	47.83	2.19
14	BLw14	45.68	0.12	6.70	7.20	0.60	12.80	44.70	1.60
15	BLw15	37.88	0.15	5.90	7.10	0.60	7.80	42.10	0.53
16	BLw16	45.85	0.25	11.00	12.2	0.20	8.20	55.15	5.75
17	BLw17	22.18	0.16	4.55	5.30	0.40	11.80	19.05	0.94
18	BLw18	33.88	0.16	8.67	9.10	0.20	8.20	42.37	1.04
19	BLw19	41.68	0.13	10.34	12.50	0.40	8.00	49.19	7.06
20	BLw20	26.75	0.15	8.40	7.60	0.40	6.80	34.92	0.78
21	BLw21	25.48	0.11	6.10	6.90	0.60	14.60	22.43	0.86
22	BLw22	26.41	0.12	6.50	5.77	0.40	9.20	28.47	0.73
23	BLw23	37.83	0.14	8.28	7.35	0.80	9.70	41.36	1.74
24	BLw24	38.69	0.16	8.00	7.52	0.50	8.40	43.29	2.18
25	BLw25	51.69	0.11	6.00	6.50	0.40	12.50	49.31	2.09
26	BLw26	47.8	0.13	9.20	9.10	0.20	8.00	56.16	1.87
27	BLw27	35.75	0.15	7.40	8.20	0.60	6.80	42.45	1.65
28	BLw28	34.05	0.12	7.00	7.58	0.40	10.80	35.73	1.82
29	BLw29	31.27	0.11	6.20	7.00	0.40	9.60	33.26	1.32
30	BLw30	30.63	0.15	8.05	7.37	0.40	9.60	34.62	1.58
31	BLw31	44.33	0.2	22.85	20.72	0.40	6.80	73.91	6.99
32	BLw32	37.74	0.16	21.33	20.87	0.40	8.00	64.60	7.10
33	BLw33	45.13	0.32	23.26	22.00	0.40	7.60	74.62	8.09
34	BLw34	32.93	0.19	5.38	6.20	0.80	12.50	33.86	0.54
35	BLw35	19.61	0.06	4.00	5.78	0.60	13.15	14.21	1.49
36	BLw36	37.84	0.12	8.00	6.72	0.20	9.60	41.66	1.22
37	BLw37	42.85	0.14	9.58	10.63	0.40	8.20	51.56	3.04
38	BLw38	51.46	0.25	13.42	11.45	0.40	9.00	61.53	5.65
39	BLw39	55.13	0.23	11.00	9.84	0.40	7.60	63.80	4.40
40	BLw40	49.22	0.15	14.28	11.45	0.60	9.20	59.54	5.76
Mean		37.66	0.16	9.82	9.86	0.44	10.01	44.44	2.68
Maximum		55.13	0.32	27.40	28.00	0.80	17.60	80.15	8.09
Minimum		16.80	0.06	3.36	3.54	0.20	6.80	11.25	0.53

Classification of ground irrigation water of Bilara tehsil of Jodhpur district

On the basis of combined effect of salinity (EC), sodicity (SAR) and alkalinity (RSC) of the irrigation water characteristics proposed by Gupta (1979) [10], consisting of seven classes *viz.* good, marginally saline, saline, high-SAR saline, marginally alkali, alkali and high alkali was used for present study. It is evident from the data of ground irrigation water of study area given table 3, that 15, 70 and 15 per cent water samples fall under classes of saline, high-SAR saline and marginally alkali classes, respectively. The dominant class in studied area was high-SAR saline water being about 70 per cent water samples are under this class.

Table 5: Classification of groundwater quality on the basis of EC, SAR and RSC of Bilara tehsil of Jodhpur and their recommended management practices

S. No.	Water quality	Per cent of samples	Sample No.	Recommended management practices
1.	Good (EC<2 dSm^{-1}, SAR <10 and RSC <2.5 mel^{-1})	-	-	-
2.	Marginally saline (EC 2-4 dSm^{-1}, SAR<10 and RSC <2.5 mel^{-1})	-	-	-
3.	Saline (EC >4 dSm^{-1}, SAR<10 and RSC < 2.5 mel^{-1})	15	BLw7, BLw8, BLw20, BLw31, BLw32, BLw33	Can be used with slight salt tolerant crops and periodic monitoring salts
4.	High- SAR saline (EC > 4 dSm^{-1}, SAR	70	BLw2, BLw5, BLw6, BLw9, BLw10, BLw11, BLw12,	Unsuitable for irrigation but

	>10 and RSC <2.5 mel^{-1})		BLw13, BLw14, BLw15, BLw16, BLw18, BLw19, BLw22, BLw23, BLw24, BLw25. BLw26, BLw27, BLw28, BLw29, BLw30, BLw34, BLw36, BLw37, BLw38, BLw39, BLw40	blending and conjunctive use with good irrigation water if available.
5.	Marginally alkali (EC < 4 dSm^{-1}, SAR< 10 and RSC 2.0-4.0 mel^{-1})	15	BLw1, BLw3, BLw4, BLw17, BLw21, BLw35	Can be used with periodic monitoring of gypsum requirement
6.	Alkali (EC < 4 dSm^{-1}, SAR< 10 and RSC >4.0 mel^{-1})	-	-	-
7.	Highly alkali (EC <4 dSm^{-1}, SAR> 10 and RSC > 4.0 mel^{-1})	-	-	-

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