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Charan Singh
Department of Soil Science and Agricultural Chemistry, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

SR Yadav
Department of Soil Science and Agricultural Chemistry, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

Gajendra Kumar Meena
Department of Soil Science and Agricultural Chemistry, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

Gopal Lal Dhaker
Department of Soil Science and Agricultural Chemistry, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

Correspondence
Charan Singh
Department of Soil Science and Agricultural Chemistry, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

Characterization of ground irrigation water quality of Piparcity tehsil of Jodhpur district, Rajasthan

Charan Singh, SR Yadav, Gajendra Kumar Meena and Gopal Lal Dhaker

Abstract
In present study, ground irrigation water quality of Pipar City tehsil of Jodhpur district of Rajasthan was examined for irrigation purpose. Forty irrigation water samples were collected from different villages of Pipar City tehsil. The irrigation water samples were analysed for various chemical properties like EC, pH, major cations: Na^{+}, Ca^{+2}, Mg^{+2}, K^{+} and anions: CO_3^{-2}, HCO_3^{-}, Cl^{-} and SO_4^{-2}. The irrigation water was classified into three groups on the basis of salinity (EC), sodicity (SAR) and alkalinity (RSC). Besides this, the quality of irrigation water was also categorized on the basis of the EC, SAR and RSC into four classes viz. good, marginally saline, high SAR saline and high alkali water. The results showed that 10 per cent were good, 17.50 per cent were marginally saline, 60 per cent were high-SAR saline and 12.50 per cent water samples were highly alkali, and it was found that majority of irrigation water of the study area were not suitable for irrigation purposes of normal and sensitive crops.

Keywords: Underground irrigation water, salinity, sodicity, classification

Introduction
India is the largest user of ground water in the world, with an estimated use of 230 cubic kilometres of ground water every year i.e. more than a quarter of the global total. Ground water has rapidly emerged to occupy a dominant place in India's agriculture and food security in the recent years. It has become the main source of growth in irrigated area over the past three decades and now it accounts for over 60% of the irrigated area in the country. It is estimated that over 70% of India's food grain production comes from irrigated agriculture, in which ground water plays a major role (Gandhi and Namboodiri, 2009) [9].

The ground water available for irrigation is estimated to be about 86% of this or 36.42 million hectare-meters (after allowing 14% for domestic, industrial and other uses). Out of this, the utilizable ground water resources for irrigation are 32.77 million hectare meters or 90%. Over the last two decades, 84% of the total addition to net irrigated area came from ground water, only 16% from canals (Briscoe and Malik, 2006) [6]. Ground water, which usually varies in its salt content, has a profound impact on soil properties.

In India, 6.73 Mha of land is affected by salinity and sodicity (Singh *et al.*, 2009). About 10 Mha of land is lost because of salinity caused by irrigation water each year. Out of total cultivated cropped area in Rajasthan, 1.183 Mha of land is salt affected (AICRP, 2010) [1].

Of late, due to the inadequacy of surface water, the ground water is becoming more and more important which is supplementing the total water needs especially under rainfed situations. As reported by Gupta (2008) [10], 70 and 80% of India's irrigation and domestic water supplies come from groundwater rather than from surface water. Although groundwater is widely distributed and renewable resources of the earth but the quality of this is not assured. Excessive pumping, low recharge, wrong agricultural practices have led to the situation of shrinkage groundwater and groundwater becoming brackish at some places of Sangrur, Punjab (Venu and Rishi, 2010) [21].

Materials and Methods
The Pipar City tehsil is situated in the south-eastern part of the Jodhpur district between latitudes of 26°20'144" and 26^{0} 25'35.200" N and Longitudes of 73°25'902" and 73°50.986'" E. It 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 eco-region with desert and saline soils) and in the II_B zone, named as transitional plain of Luni Basin. Georeferenced forty ground water samples were collected from the tube wells and open wells which were used for irrigation purpose. Water samples were either taken from the pumps or drown by bucket and collected in clean and ringed plastic bottles labelled properly and carefully corked brought to the laboratory for further analysis. In the laboratory, the water samples were analyzed like EC, pH, major cations: Na^+, Ca^{+2}, Mg^{+2}, K^+ and anions: CO_3^{-2}, HCO_3^-, Cl^- and SO_4^{-2}. The values of SAR and RSC were also calculated. All the parameters were analyzed by using standard methods outlined by Richards (1954) [17].

Results and Discussion

The pH of irrigation water of Pipar City tehsil of Jodhpur district varied from 7.10 to 9.13 with a mean value of 7.84 (Table 1). It showed that ground water of that area was slightly alkaline in nature. Similar results were supported by the findings of Singh *et al.* (1994) [19], Babaria *et al.* (2005) [3], Kishor *et al.* (2006) [13] and Chopra *et al.* (2014) [7]. The electrical conductivity of the irrigation waters of study area varied between 0.56 to 19.50 dS m^{-1} with mean value of 5.27 dS m^{-1} (Table 1). According to the United State Salinity Laboratory Staff (1954) the EC of that area ranged from moderate to very high. Similar results were supported by the findings of Vyas *et al.* (1993) [22], Singh *et al.* (1994) [19], Kishor *et al.* (2006) [13], Khan and Sharma (2007) [12] and Bali *et al.* (2015) [5].

Table 1: Ground water chemical characteristics in Pipar City tehsil of Jodhpur

S. No.	Sample code no.	pH	EC (dS m^{-1})	SAR	RSC (me L^{-1})	pHc	Adj. SAR
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	PIW_1	7.43	7.96	37.73	0.6	7	88.67
2	PIW_2	7.31	10.37	40.10	0.6	6.6	110.47
3	PIW_3	7.42	3.2	9.97	0	6.9	24.25
4	PIW_4	7.43	6.33	28.50	1.4	6.9	71.24
5	PIW_5	7.84	4.81	26.47	1.5	7.1	60.88
6	PIW_6	7.55	4.07	19.53	2	7.1	44.92
7	PIW_7	7.75	2.59	9.79	0	6.9	24.48
8	PIW_8	7.63	2.48	9.95	1.8	6.9	24.88
9	PIW_9	7.72	2.8	12.92	0.4	7	23.95
10	PIW_{10}	7.12	3.97	19.56	2.4	7	46.95
11	PIW_{11}	9.13	4.92	34.55	4.2	7.4	69.09
12	PIW_{12}	7.45	6.2	28.28	2.4	6.9	70.7
13	PIW_{13}	8.45	9.47	47.55	1.2	7	114.11
14	PIW_{14}	7.13	4.5	23.37	0.4	7.2	51.42
15	PIW_{15}	8.12	3.99	25.21	4.2	7.2	55.46
16	PIW_{16}	8.15	3.56	20.83	4.1	7.1	47.92
17	PIW_{17}	8.13	1.28	2.90	0.6	6.8	7.54
18	PIW_{18}	7.63	10.54	32.75	0.6	6.3	101.54
19	PIW_{19}	8.06	5.23	29.26	4.1	7.1	67.3
20	PIW_{20}	7.42	7.7	43.29	1.2	7.1	99.56
21	PIW_{21}	7.73	4.95	24.97	0.2	7.1	57.43
22	PIW_{22}	7.1	4.13	22.23	0.2	7.2	48.91
23	PIW_{23}	7.1	0.7	4.07	1	7.6	7.33
24	PIW_{24}	7.91	0.56	2.10	0.2	7.5	3.98
25	PIW_{25}	7.41	6.55	42.99	0.4	7.5	81.68
26	PIW_{26}	7.45	6.69	41.87	0.6	7.4	83.74
27	PIW_{27}	7.35	5.89	39.76	0.6	7.5	75.54
28	PIW_{28}	7.62	2.17	9.88	1.2	7	23.71
29	PIW_{29}	8.3	19.5	76.08	1.5	6.5	220.63
30	PIW_{30}	7.95	5.82	36.09	1.2	7.3	75.79
31	PIW_{31}	7.95	2.18	9.84	0.8	7	23.62
32	PIW_{32}	7.7	2.56	9.67	0	7.2	21.27
33	PIW_{33}	7.93	1.32	8.27	1.2	7.4	16.54
34	PIW_{34}	7.75	6.1	41.38	0.4	7.5	78.62
35	PIW_{35}	7.4	6.77	52.48	0.2	7.7	89.22
36	PIW_{36}	8.75	3.12	24.46	4.1	7.4	48.42
37	PIW_{37}	7.6	4.78	30.89	2	7.4	61.77
38	PIW_{38}	7.9	4.16	25.01	1.6	7.3	52.51
39	PIW_{39}	7.43	8.86	61.38	0.7	7.5	116.61
40	PIW_{40}	7.73	8.05	52.54	1.6	7.3	110.34
Mean		7.22	5.27	27.96	1.34	7.14	62.57
Maximum		9.13	19.50	76.08	4.20	7.70	220.63
Minimum		7.1	0.56	2.10	0.00	6.30	3.98

The SAR values of the studied area ranged between 2.10 to 76.08 with a mean value of 27.96 (Table 1). Increased in SAR values of irrigation water with the increase in pH and EC of irrigation water might be due to dominance of soluble Na^+ over Ca^{2+}, Mg^{2+}. Similar results were also obtained by Shankarnarayan *et al.* (1965), Puntamka *et al.* (1967) [16] and Bagoria (2002) [4].

The RSC indicates the excess of CO_3^{2-} and HCO_3^- over Ca^{2+} and Mg^{2+} in irrigation water. The data presented in Table 1 reveal that RSC values of irrigation waters varied from nil to

4.20 me L^{-1}. The negative value of RSC indicated that the combined concentration of Ca^{2+} and Mg^{2+} was more than the addition of CO_3^{2-} and HCO_3^-. In Pipar City tehsil few samples were high in RSC. Similar results were supported by the findings of Das *et al*. (2010) [8], Muhammad *et al*. (2013) [14].

pH_c of irrigation water refers to a theoretical, calculated value of pH in contact with lime and equilibrium with soil CO_2. The data presented in table 1 indicated that pH_c values of irrigation waters varied from 6.3 to 7.7 with a mean value of 7.14. These low values of pH_c indicate the tendency to precipitate lime from the applied water. Similar results were also reported by Wilcox (1966) [20], Ayers and Westcot (1976) [2] and Oswal (1999) [15]. In Adj. SAR the effects of excessive sodium of high HCO_3^- or CO_3^{-2} of total salts load of the water were taken into consideration. The calculated values of Adj. SAR of irrigation water varied from 3.98 to 220.63 with a mean value of 62.57. 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), Wapda (1974), Sharma and Mondal (1981), Ram (1996), Oswal (1999) [15] and Ram (2003).

On the basis of combined effect of salinity(EC), sodicity (SAR) and alkalinity (RSC) of the irrigation water characteristics proposed by Gupta *et al.* (1994), 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 2 that 10, 17.50, 60 and 12.50 per cent water samples fall under classes of good, marginally saline, high-SAR saline and highly alkali classes, respectively. The dominant class in studied area was high-SAR saline water being about 60 per cent water samples are under this class.

Table 2: Classification of groundwater quality on the basis of EC, SAR and RSC of Pipar City 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 dS m^{-1}, SAR <10 and RSC <2.5 me L^{-1})	10	4	Can be used for all type of soils and crops
2.	Marginally saline (EC 2-4 dS m^{-1}, SAR<10 and RSC <2.5 me L^{-1})	17.50	7	Can be used with slight salt tolerant crops and periodic monitoring salts
3.	Saline (EC >4 dS m^{-1}, SAR<10 and RSC < 2.5 me L^{-1})	-	-	-
4.	High- SAR saline (EC > 4 dS m^{-1}, SAR >10 and RSC <2.5 me L^{-1})	60	24	Unsuitable for irrigation but blending and conjunctive use with good irrigation water if available.
5.	Marginally alkali (EC < 4 dS m^{-1}, SAR< 10 and RSC 2.0-4.0 me L^{-1})	-	-	-
6.	Alkali (EC < 4 dS m^{-1}, SAR< 10 and RSC >4.0 me L^{-1})	-	-	-
7.	Highly alkali (EC <4 dS m^{-1}, SAR> 10 and RSC > 4.0 me L^{-1})	12.50	5	Unsuitable for irrigation

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