

QUALITY CLASSIFICATION OF GROUNDWATERS OF WESTERN RAJASTHAN

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ABSTRACT

An integrated classification of quality of groundwater based upon EC, SAR and RSC values of 4145 water samples has been made to evaluate water quality for irrigation in 11 districts of western Rajasthan. It is observed that groundwaters are sodic in character due to high SAR or RSC values. The SAR ranges from 0.15 to 176.8 with an average value of 13.9. In districts Barmer, Bikaner and Jaisalmer more than 33.3 per cent waters have SAR more than 18. High RSC generally occurs in low to medium salinity waters and ranges from nil to 68.8 meL⁻¹ with an average value of 3.1 meL⁻¹. The districts viz., Jhunjhunu, Nagaur and Sikar have high RSC in ground waters. Based upon salinity, SAR and RSC distribution, the whole region has been divided in six saline-sodic zones.

INTRODUCTION

Groundwater in western Rajasthan is inherited by diversity of quality problems (Gupta and Vijaya 1988). Occupying largely the area of Indian Thar Desert, the region is characterised by arid climate conditions and thus the groundwater is often deep and saline. It also contains high sodium causing thereby problem of sodicity. Though, the attempts to classify the waters for agriculture have been made in past by several scientists, these studies mostly emphasize the problem and distribution of salinity (Paliwal 1971; Dhir 1977; Gupta 1979) and lack in providing detailed information regarding distribution pattern of sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) which are considered as important sodicity or alkalinity indices for irrigation waters. The present study is therefore an attempt to classify groundwaters of the region on the basis of these two indices taken along with salinity.

MATERIAL AND METHODS

Four thousand one hundred and forty five groundwater samples representing various hydrogeological aquifers were collected from all the 11 districts of western Rajasthan during the detailed hydrogeological investigations carried out by Ground Water Department during the period 1976 to 1986. These samples were analysed chemically for all major parameters as per standard methods. SAR and RSC were

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calculated to know the sodicity and alkalinity in groundwaters. The waters were classified in three salinity and SAR classes viz., low, medium and high depending upon their values as ≤ 3.0 , 3.0 to 5.0 and > 5.0 dSm^{-1} for salinity; and ≤ 10 , 10 to 18 and > 18 for SAR. Similarly, the waters were classified as low or high RSC depending upon their values viz. < 2.5 and > 2.5 meL^{-1} . The salinity classification is based upon Gupta (1979) which has also been adopted by ICAR for arid and semi-arid regions (Anonymous 1986). The classifications commonly in vogue (Dhir 1977; Richards 1954) have been taken for evaluating distribution of SAR and RSC.

RESULTS AND DISCUSSION

The classification on the basis of salinity, SAR and RSC is shown in Tables 1 & 2. It is seen that both salinity and sodicity are widely distributed in groundwaters. Nearly 54 per cent waters in the region have SAR more than 10. In Barmer, Jaisalmer and Bikaner districts the frequency of occurrence of high SAR waters is even more. In these districts, more than 33.3 per cent waters have SAR higher than 18. The main reason for high SAR in groundwaters is their sodium dominating character. In higher salinity range the sodium is associated mainly with chloride and sulphate, whereas in low to medium salinity waters it is associated with carbonate and bicarbonate. This causes problem of high RSC in these waters. Groundwaters in Sikar, Jhunjhunu and Nagaur districts in eastern region are characterised by such waters. Besides these districts, ground waters in Barmer and Jaisalmer districts have also significant concentration of RSC. In general, the SAR in groundwaters ranges from 0.15 to 176.8 with an average value of 13.9 and RSC ranges from nil to 68.8 meL^{-1} .

Saline Sodic Zones

The adverse effect of high SAR and RSC in irrigation waters is well known. Although, there may be contradicting views regarding their upper permissible limits on sandy or sandy loam soils of western Rajasthan, but there are no two opinions about their detrimental effects when present in higher concentration and continuous use. Joshi and Dhir (1989) have observed that continuous use of waters having RSC between 15 to 20 meL^{-1} for 8 to 10 years on sandy loam soils in Barmer district have turned the soils completely barren. Bajwa and Manchanda (1986) inferred that classification of irrigation waters on the basis of EC, SAR and RSC values taken together depicts their inherent salinity and sodium hazard more reliably in spite of certain limitations.

Based on average values for respective district the ground waters in western Rajasthan could be divided broadly in six saline-sodic zones (Fig. 1). Each zone covers more than 2/3 area under a particular group of waters. These zones could be briefly described as below :

Table 1. Salinity distribution in groundwaters

District	No. of samples	EC (dSm ⁻¹) range and percentage distribution							
		Min.	Max.	Average	≤1.5	1.5-3.0	3.0-5.0	5.0-10.0	>10.0
Barmer	536	0.28	40.8	6.07	9.3	22.8	22.9	27.0	17.9
Bikaner	144	0.49	31.0	5.62	16.0	25.7	20.8	19.4	18.1
Churu	316	0.50	23.9	4.90	12.3	23.7	26.9	27.5	9.5
Jaisalmer	268	0.51	24.0	4.70	13.8	28.4	23.5	26.1	8.2
Jalore	165	0.43	27.0	4.90	21.2	16.4	21.2	31.5	9.7
Jhunjhunu	295	0.25	12.3	2.16	37.0	46.1	12.5	3.7	0.7
Jodhpur	704	0.28	35.5	4.23	21.6	27.4	23.3	20.7	7.0
Nagaur	1083	0.25	26.7	3.95	21.0	28.4	23.4	22.8	4.3
Pali	236	0.36	25.0	4.24	29.2	27.1	15.7	18.6	9.4
Shri Ganganagar	84	0.25	21.6	3.45	33.3	27.4	16.7	19.0	3.6
Sikar	314	0.27	15.4	2.32	42.4	30.6	19.7	6.7	0.6
Total	4145	0.25	40.8	4.25	21.8	27.9	21.8	20.9	7.6

Table 2. SAR and RSC distribution in groundwaters

District	SAR distribution and range					RSC (meL ⁻¹) distribution and range									
	Min	Max	Average	10-18		26-34		Min	Max	Average	≤2.5				
				10-	18	26	34				2.5-	5.0			
Barmer	0.15	108.7	20.6	23.9	26.7	23.1	10.6	15.7	nil	30.4	2.8	69.0	10.1	12.1	8.8
Bikaner	0.97	75.7	14.7	45.8	20.1	18.1	9.7	6.3	nil	37.8	1.2	81.9	13.9	1.4	2.8
Churu	0.59	83.0	13.5	44.0	31.0	15.8	4.4	4.7	nil	30.3	2.2	76.0	6.3	10.4	7.3
Jaisalmer	0.40	54.2	16.0	28.7	35.1	22.8	7.8	5.6	nil	18.4	2.2	69.0	11.9	16.0	3.0
Jalore	0.42	54.2	13.6	47.3	26.1	15.1	5.4	6.1	nil	20.1	1.7	78.2	7.9	10.9	3.0
Jhunjhunu	0.47	35.0	9.8	59.7	21.4	15.6	3.0	0.3	nil	19.4	3.9	53.9	11.5	22.0	12.5
Jodhpur	0.20	100.6	12.3	51.8	28.1	10.8	5.3	4.0	nil	55.2	2.1	77.4	10.1	7.1	5.4
Nagaur	0.20	176.8	14.7	44.6	27.1	14.9	6.5	6.9	nil	68.8	4.6	54.8	12.9	15.5	16.8
Pali	0.43	51.6	12.2	52.5	21.6	11.4	9.7	4.7	nil	22.6	2.0	75.8	8.5	9.3	6.4
Shri Ganga-nagar	0.50	37.7	7.7	73.8	16.6	3.6	3.6	2.4	nil	18.6	1.3	86.9	4.8	3.6	4.7
Sikar	0.26	84.2	8.6	67.5	19.1	9.6	2.5	1.3	nil	25.3	3.8	62.1	7.6	14.3	15.9
Total	0.15	176.8	13.9	46.1	26.2	15.2	6.4	6.1	nil	68.8	3.1	67.2	10.4	12.4	10.0

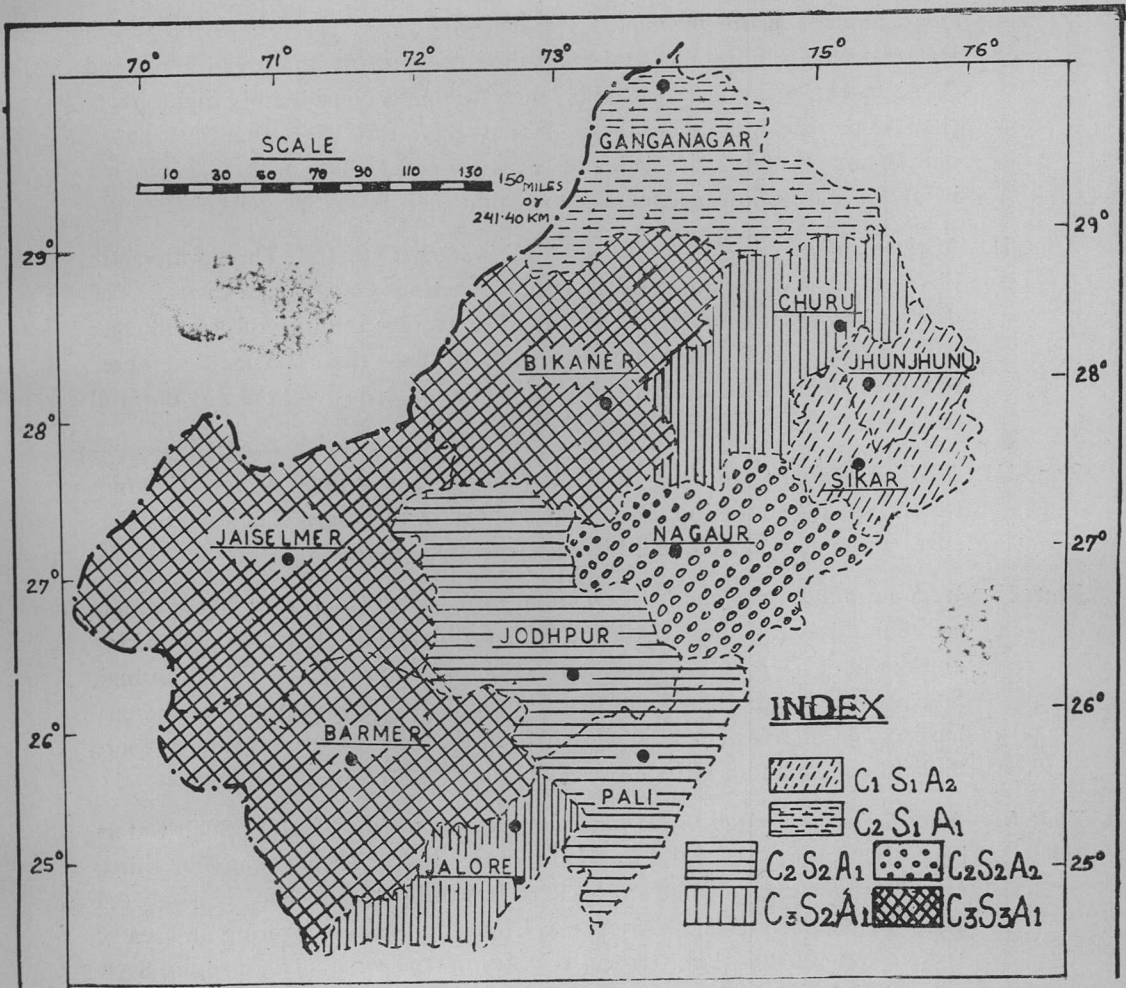


Fig. 1. Saline—Sodic zones of groundwaters in western Rajasthan

EC (dSm⁻¹) : C₁ ≤ 3; C₂ 3-5; C₃ > 5

SAR : S₁ ≤ 10; S₂ 10-18; S₃ > 18

RSC (meL⁻¹) : A₁ < 2.5; A₂ > 2.5

- Zone I. *Low salinity, low to medium SAR and high RSC waters ($C_1S_1A_2$)* : Such waters occur in Jhunjhunu and Sikar districts covering an area of 5,928 and 7,732 sq km, respectively. RSC in these waters is considerably high. More than 40 per cent waters in these districts have RSC more than 2.5 meL^{-1} and at many places its value exceeds 10 meL^{-1} . Use of these waters for irrigation requires proper management practices.
- Zone II. *Medium salinity, low SAR and low RSC waters ($C_2S_1A_1$)* : These waters are observed in extreme north of the region covering Ganganagar district. The district has an area of 20,629 sq km. The average salinity of groundwater is 3.5 dSm^{-1} , SAR less than 10 and RSC less than 2.5 meL^{-1} . These waters could be used for irrigating semi-tolerant crops without any harmful sodic effects.
- Zone III. *Medium salinity, medium SAR and low RSC waters ($C_2S_2A_1$)* : Groundwaters in Jodhpur and Pali districts fall in this zone. The two districts cover an area of 22,860 and 12,300 sqkm, respectively.
- Zone IV. *Medium salinity, medium SAR and high RSC waters ($C_2S_2A_2$)* : These waters are characterised by both SAR and RSC problems. Nagaur district covering an area of 17,718 sqkm falls in this zone of water quality. Owing to high SAR and RSC, the groundwaters in the district, have potential sodicity hazard. At many places in the district, the RSC of groundwater is more than 10 meL^{-1} and SAR is more than 26.
- Zone V. *High salinity, medium SAR and low RSC waters ($C_3S_2A_1$)* : Such waters have high salinity ($>5.0 \text{ dSm}^{-1}$) in more than 33.3 per cent (one-third) samples but average value of SAR is less than 18 and RSC is below 2.5 meL^{-1} . Groundwaters in districts viz. Churu and Jalore covering an area of 16,860 and 10,640 sqkm, respectively fall in this zone. The medium SAR values which are usually associated with high salinity may develop moderate alkaline conditions in soils.
- Zone VI. *High salinity, high SAR and low RSC waters ($C_3S_3A_1$)* : This zone is occupied by Barmer, Bikaner and Jaisalmer districts occupying extreme western part of the region. The three districts cover an area of 28,387; 27,231 and 38,384 sq km, respectively and have mostly arid climate. More than 33.3 per cent waters in this zone have high EC ($>5.0 \text{ dSm}^{-1}$) and high SAR (>18). The average EC of groundwaters ranges from 4.7 dSm^{-1} in Jaisalmer district to 6.07 dSm^{-1} in Barmer district. Similarly, average SAR ranges from 14.7 in Bikaner district to 20.6 in Barmer district. Nearly 30 per cent waters in these two districts have been found to contain RSC higher than 2.5 meL^{-1} . These waters also have high salinity and high SAR. Occurrence of high SAR and RSC along with salinity is responsible for alkalinity

development in soils in part of Barmer district as observed by Joshi and Dhir (1989).

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