

## Assessment of Ground Water Quality in Churu District, Rajasthan

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**Abstract:** Ground water quality for irrigation under different hydrogeological formations in Churu District of Rajasthan has been assessed on the basis of 258 ground water samples. SAR and RSC values, deciding factors of water quality for irrigation purpose, have been worked out. The ground water is largely sodic due to medium to high SAR ranging from 0.05 to 68.11 with an average value of 16.28. About 67% of waters have SAR less than 18. Higher values of SAR generally found in Alluvium and Schist/Phyllite aquifers. Salinity in ground water is generally high, 77% samples have EC more than  $3.0 \text{ dS m}^{-1}$ . Due to high salinity the RSC is low in most of the samples and range from 0.0 to  $26.0 \text{ MeL}^{-1}$ . About 79% of the water samples have RSC less than  $2.5 \text{ MeL}^{-1}$ . Based on the above water quality parameters Churu District have been classified in to four sodic-saline zones C1S1R1, C2S1R1, C2S2R1 and C3S3R1 for adopting soil amelioration strategies for irrigated agriculture.

**Key words:** Ground water quality, hydrogeological formation, salinity, sodicity, alkalinity.

In many situations, ground water quality is a major constraint in developing irrigated agriculture (Oster and Jayawardane, 1998). The chemical characteristics of ground water are largely dependent on hydrogeological formations (Oster *et al.*, 1999; Saxena *et al.*, 2003). Indian arid zone of Rajasthan is characterized with deep and generally saline ground water. At many places medium to high sodicity is a major problem. In the past, several researchers have made attempts to classify the water for agriculture, but mostly emphasized the problem and distribution of salinity (Paliwal, 1971; Dhir, 1977; Gupta, 1979). These studies lack information on distribution pattern of sodium adsorption ratio (SAR) and residual sodium carbonate (RSC), which are considered important sodicity and alkalinity indicators for irrigation water. In the present study an attempt has been made to classify

ground water quality of the Churu District of Rajasthan on the basis of SAR and RSC along with salinity. Attempts have also been made to classify saline-sodic zones in different hydrogeological formations.

### Materials and Methods

Churu District of Rajasthan, covering an area of 13858.9 sq. km, is located between  $73^{\circ} 40'$  and  $75^{\circ} 39'$  east longitude and  $27^{\circ} 25'$  and  $29^{\circ} 00'$  north latitude. The climate of the district is extreme and drought is frequent. It is very hot in summer and cold in winter. Minimum temperature ranges from as low as  $0^{\circ}$  to  $26.5^{\circ}\text{C}$  with average of  $13.5^{\circ}\text{C}$ , while maximum temperature ranges from  $22.6^{\circ}$  to  $47.4^{\circ}\text{C}$  with average of  $32.5^{\circ}\text{C}$ . The average annual potential evapotranspiration in the district is more than 2000 mm whereas, the average rainfall is only 370 mm. The rock formations in

the district range from Pre-Cambrian to Recent and few isolated hills belong to Delhi Super group and Post Delhi intrusive are exposed in the southern part of the district. The hydrogeology of the district in the western part is marked by the sedimentary sequence comprised of Marwar Supergroup (Jodhpur, Bilara and Nagaur Groups) and Tertiary deposits including sandstone, shale, claystones, gravel beds, etc. These are overlain by the alluvium deposits of recent age. In the eastern part alluvium is the major hydrogeological formation (Fig. 1).

During 2001-2004 a total 258 ground water samples were collected from observation wells located in different formations (aquifers), were analyzed for major chemical constituents as per standard methods. SAR and RSC were determined to know the sodicity and alkalinity levels in ground water. On the basis of salinity (EC) ground water was classified into three classes viz. Low (C1), medium (C2)

and high (C3) having EC values less than 3, 3-5, and more than 5  $\text{dS m}^{-1}$ , respectively. Similarly, three classes of SAR have been adopted as low (S1: <10), medium (S2: 10-18) and high (S3: >18), following the ground water quality standards for arid and semi-arid regions (Gupta, 1979; Anonymous, 1986). The RSC in water is classified as low (R1: <2.5  $\text{MeL}^{-1}$ ) and high (R2: >2.5  $\text{MeL}^{-1}$ ). The classification in vogue (Dhir, 1977; Richards, 1954) have been taken for evaluating distribution of SAR and RSC.

## Results and Discussion

### *Distribution of salinity*

It is observed that the salinity in the Tertiary formation, Nagaur sandstone and in Bilara limestone aquifers was low having EC value <3.0  $\text{dS m}^{-1}$  (Table 1). High porosity and permeability of these formations together with presence of joints/fractures and cavernous nature of the Bilara

Table 1. Distribution of different parameters

Parameters	Aquifer (No. of samples/Area of aquifer sq. km)						Overall (258/ 13858.89)
	Alluvium (185/ 9654.34)	Tertiary (5/245.63)	Nagaur Sandstone (9/911.32)	Bilara Limestone (4/465.00)	Jodhpur Sandstone (32/1750.00)	Schist/ Phyllite (23/832.00)	
Salinity/EC $\text{dS m}^{-1}$							
Minimum	1.76	1.73	0.55	1.28	1.45	2.64	0.55
Maximum	18.41	2.01	3.7	2.71	12.75	9.39	18.41
Average	6.58	1.54	2.53	1.77	4.56	4.82	5.85
SAR							
Minimum	0.05	4.99	2.07	2.01	1.67	0.68	0.05
Maximum	68.11	11.68	12.15	4.51	34.30	36.71	68.11
Average	19.81	7.08	5.52	2.61	12.75	8.59	16.92
RSC							
Minimum	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Maximum	26.00	4.2	3.6	0.44	13.58	5.60	26.00
Average	1.77	1.72	0.49	0.11	1.65	0.51	1.57

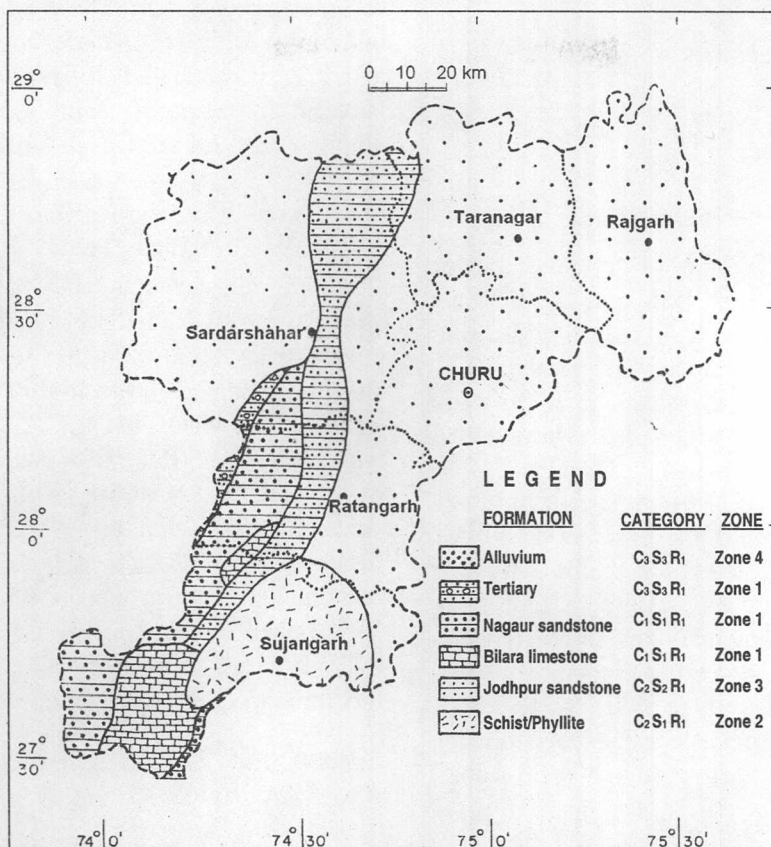


Fig. 1. Ground water quality variation under different hydrological formations in Churu District of Rajasthan.

limestone attributes low mineralization in ground water. However, geographically these formations are distributed in limited area and cover only about 12% area of the total district. The average EC of ground water is  $5.85 \text{ dS m}^{-1}$  with 82% water samples having  $\text{EC} > 3.0 \text{ dS m}^{-1}$ , which suggests that the ground water in the district is largely saline.

#### Distribution of SAR

It is also observed that sodicity is widely distributed in ground water. In general SAR

is  $< 18$  in the Tertiary formation, Nagaur sandstone and in Bilara limestone aquifers, whereas, in about 40% samples in alluvium and 55% samples in Jodhpur sandstone the SAR value is  $> 18$ , indicating poor ground water quality. Higher SAR value in alluvium and Jodhpur sandstone suggests sluggish movement of ground water in these formations due to presence of high clay content and/or shale horizons causing more mineralization. The SAR values in the district range from 0.05 to 68.1 with an average of 16.9.

### *Distribution of RSC*

RSC in general is not a major quality problem, as about 80% area of the district has RSC  $<2.5 \text{ MeL}^{-1}$ , ranging from 0 to  $26.0 \text{ MeL}^{-1}$  with an average of  $1.57 \text{ MeL}^{-1}$ .

### **Classification of Saline-sodic Zones**

The continuous use of ground water for irrigation with high RSC and SAR leads to soil degradation and reduction in crop productivity. Continuous use of the water having RSC over  $15 \text{ MeL}^{-1}$  for 8-10 years on sandy soils in Barmer District have turned the land completely barren (Joshi and Dhir, 1989). However, the classification of irrigation water on the basis of EC, SAR and RSC values taken together depicts their inherent salinity and sodium hazard more distinctly than any individual or combination of two in spite of certain limitations. Thus, on the basis of average values of EC, SAR and RSC Churu District has been divided in the following four saline-sodic zones.

#### *Zone-1. Low salinity, low SAR and Low RSC water (C1S1R1)*

Such water occurs in the Tertiary formation, Nagaur sandstone and in Bilara limestone aquifers covering an area of  $1612.6 \text{ sq. km}$  and occupy western margin of the district. In this zone the average salinity in the ground water is  $2.1 \text{ dS m}^{-1}$ , SAR is  $<10$  and RSC is  $<2.5 \text{ MeL}^{-1}$ . Thus, the ground water is classified as good quality and suitable for irrigation without any harmful sodic effect.

#### *Zone-2. Medium salinity, low SAR and Low RSC water (C2S1R1)*

This particular class of water is observed in the Schist and Phyllite aquifers located in the southern part of the district covering

an area of  $832 \text{ sq. km}$ . The average salinity of ground water is  $4.82 \text{ dS m}^{-1}$ , SAR  $<10$  and RSC is  $<2.5 \text{ MeL}^{-1}$ . The water could be used for irrigating semi-tolerant crops without any harmful sodic effect.

#### *Zone-3. Medium salinity, medium SAR and Low RSC water (C2S2R1)*

In the district this class of water is associated with sandstone of Jodhpur group covering an area of  $1751 \text{ sq. km}$  in a shape of elongated strip. In this zone about 60% of the water has EC  $>3.0 \text{ dS m}^{-1}$  with an average value of  $4.6 \text{ dS m}^{-1}$ , 60% of samples have SAR  $>10$  with an average value of 12.75 and about 72% samples have RSC  $<2.5 \text{ MeL}^{-1}$ . Therefore, continuous use of ground water for longer period may cause moderate sodicity. Semi-tolerant crops with soil amelioration is recommended in this zone.

#### *Zone-4. High salinity, high SAR and Low RSC water (C3S3R1)*

The alluvium aquifer contains this particular class of water and occupies the maximum area of  $9654.3 \text{ sq. km}$  (70%) in the district. The ground water has high salinity and high SAR values. About 44% of the samples have EC  $>5.0 \text{ dS m}^{-1}$  with an average value of  $6.58 \text{ dS m}^{-1}$ , whereas 41% samples have SAR  $>18$  with an average value of 19.8, reflecting sodicity in the soil. RSC in almost 78% area of this zone is low ( $<2.5 \text{ MeL}^{-1}$ ).

### **Conclusions**

Aquifer-wise classification of ground water quality for irrigation reflects, rather vivid picture of a particular aquifer in the area. In the present study it is observed that salinity in the ground water, in general,

is high and about 82% water have EC  $>3.0 \text{ dS m}^{-1}$ . Nearly 32% ground water contains medium to high sodium causing problems of sodicity, with SAR  $>18$ . About 80% of the area has RSC  $<2.5 \text{ MeL}^{-1}$ , suggesting that RSC as such is not a quality problem in the district. However, Tertiary formation, Nagaur sandstone and Bilara limestone are the best aquifer in the district, with average EC  $<3.0 \text{ dS m}^{-1}$ , SAR  $<10$  and RSC  $<2.5 \text{ MeL}^{-1}$ . However, these formations cover only about 12% of the district area. While water quality in alluvium formation covering about 70% of the district area is poor having average EC  $6.58 \text{ dS m}^{-1}$ , SAR 19.81 and RSC  $1.77 \text{ MeL}^{-1}$ . Thus, soil amelioration on larger scale is a pre-requisite for developing irrigated agriculture in this zone. At district level, the pattern and type of crop to be grown could be decided on the basis of aquifer and/or saline-sodic zone.

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