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Assessment of Groundwater Resources in Jhunjhunun District, Rajasthan

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Abstract: An assessment of groundwater resources in Jhunjhunun district during 2005-2008 revealed that about 46% area of the district had water table at >60 m below ground level (bgl). Younger alluvium had a shallower water table (mean depth 40.63 m bgl). Ground water quality in the district is generally good (mean EC 1.88 dS m^{-1}), and is best in the younger alluvium (mean EC 0.78 dS m^{-1}). For irrigation purpose the district's groundwater could be categorized as having low salinity, medium sodicity and high alkanity (C1S2R2). The discharge from the wells varied from 40 to 120 m^3 day^{-1}. Groundwater level in the district has found to be falling at an average rate of 1.46 m y^{-1} (2001-2008). The net groundwater availability, total draft, groundwater balance and stage of groundwater development were calculated as 274.61 mcm, 525.84 mcm, (-) 251.18 mcm, and 191.5%, respectively. There is, therefore no scope for future groundwater development in the district.

Key words: Jhunjhunun, groundwater potential, quality, salinity, sodicity, irrigation class.

Groundwater is an important source of water for meeting the major water demands especially in the arid and semi-arid regions with no reliable source of surface water. Of the total groundwater extraction, more than 80% is generally used for irrigation. Groundwater quality is an important parameter for both irrigation and domestic use. Keeping in view the importance of groundwater, an assessment of the quality and quantity of groundwater in Jhunjhunun district was carried out during 2005-2008. The district is located in the northern part of Rajasthan (N 27°38′ to N 28°31′; E 75°02′ to E 76°06′ area 5915 km^2; Fig.1). The district has an arid climate with a hot summer. The average annual rainfall at district headquarter is 444.5 mm with 27 rainy days in a year. The minimum and maximum temperatures recorded are 1.0°C and 45.0°C, respectively.

Materials and Methods

A total of 309 groundwater wells samples from different locations (Fig. 2) were inventorized for depth to groundwater, well discharge and trend of groundwater table. Groundwater samples were analyzed for cations (Ca^{++}, Mg^{++}, Na^{+}, and K^{+}), anions (CO_3^{-2}, HCO_3^{-1}, and Cl^{-1}), electrical conductivity (EC), pH, sodium absorption ratio (SAR) and residual sodium carbonate (RSC), using standard laboratory methods. On the basis of EC values groundwater was classified into salinity classes viz. low (<3 dS m^{-1}), medium (3-5 dS m^{-1}) and high (>5 dS m^{-1}). Three classes of SAR were identified as: low (<10), medium (10-18) and high (>18). The RSC in water was classified as low (<2.5 me L^{-1}) and high (>2.5 me L^{-1}) as per the groundwater quality standards used for arid and semi-arid regions (Aggarwal and Ramamoorthy, 1974; Gupta, 1979). The standard classification was taken for evaluating distribution of SAR and RSC (Richards, 1954; Dhir, 1977).

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Result and Discussion

Distribution of aquifers

Major hydrogeological formations in the district are Older Alluvium (63.78%), Metamorphic rock formations of quartzite, phyllite and schist (19.96%) and Younger Alluvium (10.88%). Hilly terrain covers 5.38% area (Table 1; Fig. 3).

Younger alluvium: This formation comprises of mainly unconsolidated to semi-consolidated fine-grained sand and stream-laid deposits of clay, silt, gravel, pebbles, boulders, etc. The formation is restricted to flood plains of rivers Kantli, Udaipurwati Nadi and their tributaries. Groundwater occurs mainly under unconfined conditions. Depth to water ranges from 9.14 to 91.4 m bgl. The is shallower along the river courses and increases away from the rivers.

Fig. 1. Location of Jhunjhunun district.

Older alluvium: This is the most extensive aquifer in the district, and comprises of heterogeneous assemblage of unconsolidated to loosely consolidated sand, silt, clay and kankar, which at places contain lenses of coarse sand and gravel. Groundwater mainly occurs in the primary porosity under unconfined conditions. Groundwater level generally varied from 15.24 to 106. 6 m bgl.

Metamorphics: The rocks of Delhi Supergroup comprising mainly of quartzite, schist, phyllite, etc., form this aquifer, which has negligible primary porosity. Significant secondary porosity is introduced into them locally due to weathering and fracturing. These are represented by gneisses, schist, phyllite, quartzite, slate, and sometimes igneous rhyolite and granite, where groundwater occurrence

Table 1. Distribution of aquifers in Jhunjhunun district

Tehsil	Aquifer (Area in km^2)				Hills (km^2)
	Younger alluvium	Older alluvium	Metamorphic	Total aquifer area	
Jhunjhunun	151.9 (2.71)#	1470.6 (26.27)	0.0	1622.5 (28.99)	-
Chirawa	83.2 (1.49)	1205.5 (21.54)	12.5 (0.22)	1301.2 (23.25)	-
Nawalgarh	126.2 (2.25)	542.1 (9.69)	0.0	668.3 (11.94)	17.2
Udaipurwati	188.7 (3.37)	239.1 (4.27)	298.4 (5.33)	726.2 (12.97)	120.5
Buhana	0.0	315.5 (5.64)	325.5 (5.82)	641.0 (11.45)	12.1
Khetri	93.8 (1.68)	0.0	544.2 (9.72)	638.0 (11.40)	168.5
Total	643.8 (11.50)	3772.8 (67.41)	1180.6 (21.09)	5597.2 (100)	318.3

Figures in parenthesis indicate percentage of total aquifer area of the district.

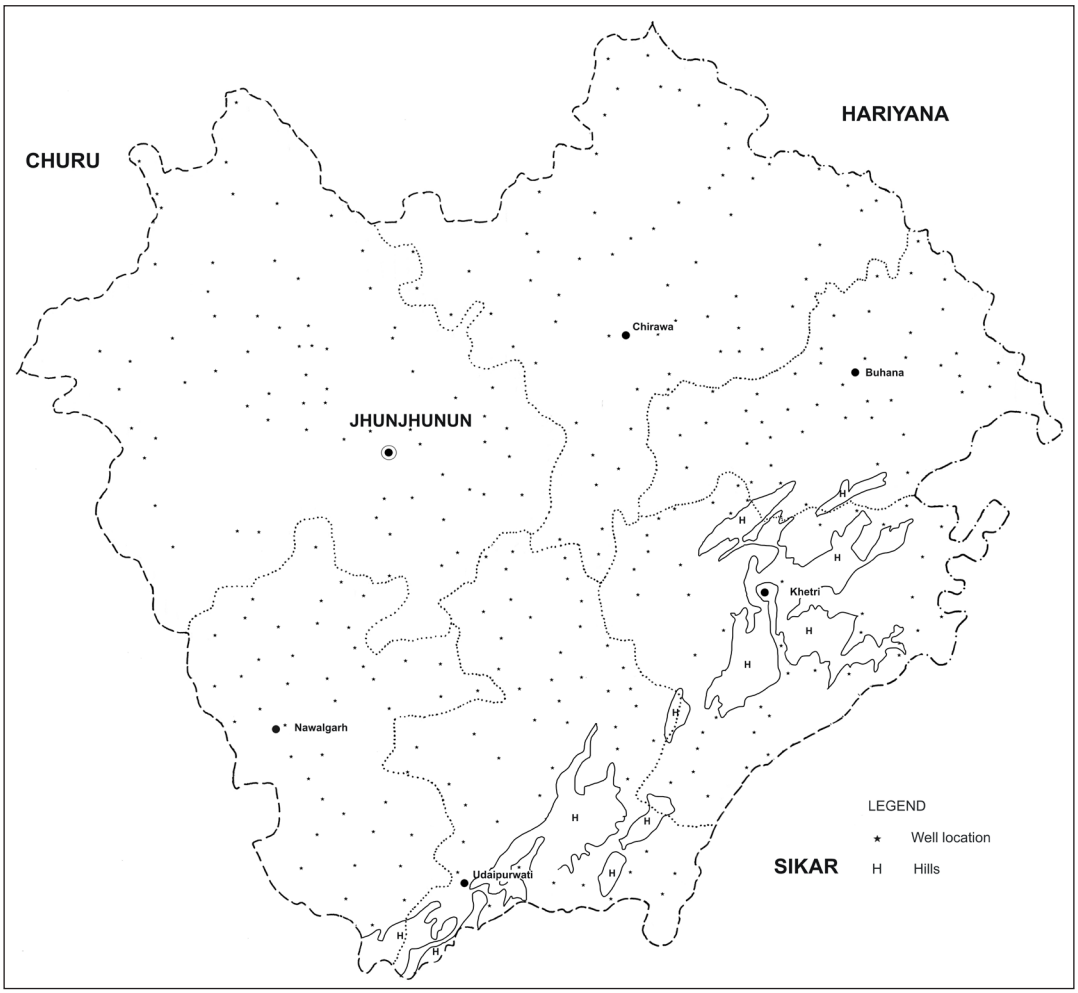

Fig. 2. Location of sample wells in Jhunjhunun district.

and movement is mainly through secondary openings like joint, fracture, weathered zone, lineament etc.

Depth to groundwater table: The depth to groundwater table in the district varies from shallow to very deep but generally it is deep to very deep. Maximum area of 2705.8 km^2 (45.74%) is covered under the depth range of >60 m bgl. About 37% area has water level in the range of 40-60 m bgl (Table 2).

The minimum and maximum water level in the district is 9.14 m (Rampur; Udaipurwati

Table 2. Area under different depth to water range in Jhunjhunun district (km^2)

Tehsil	Depth to water (m) below ground level			
	<20	20-40	40-60	>60
Jhunjhunun	-	269.9 (4.82)	1003.0 (17.92)	349.6 (6.25)
Chirawa	-	16.9 (0.30)	414.4 (7.40)	869.9 (15.54)
Nawalgarh	-	139.1 (2.49)	435.8 (7.79)	93.4 (1.67)
Udaipurwati	43.8 (0.78)#	316.5 (5.65)	225.1 (4.02)	140.8 (2.52)
Buhana	-	-	28.8 (0.51)	612.2 (10.94)
Khetri	6.3 (0.11)	227.8 (4.07)	82.3 (1.47)	321.6 (5.75)
Total	50.1 (0.90)	970.2 (17.33)	2189.5 (39.12)	2387.5 (42.66)

Figures in parenthesis indicate percentage of total aquifer area of the district.

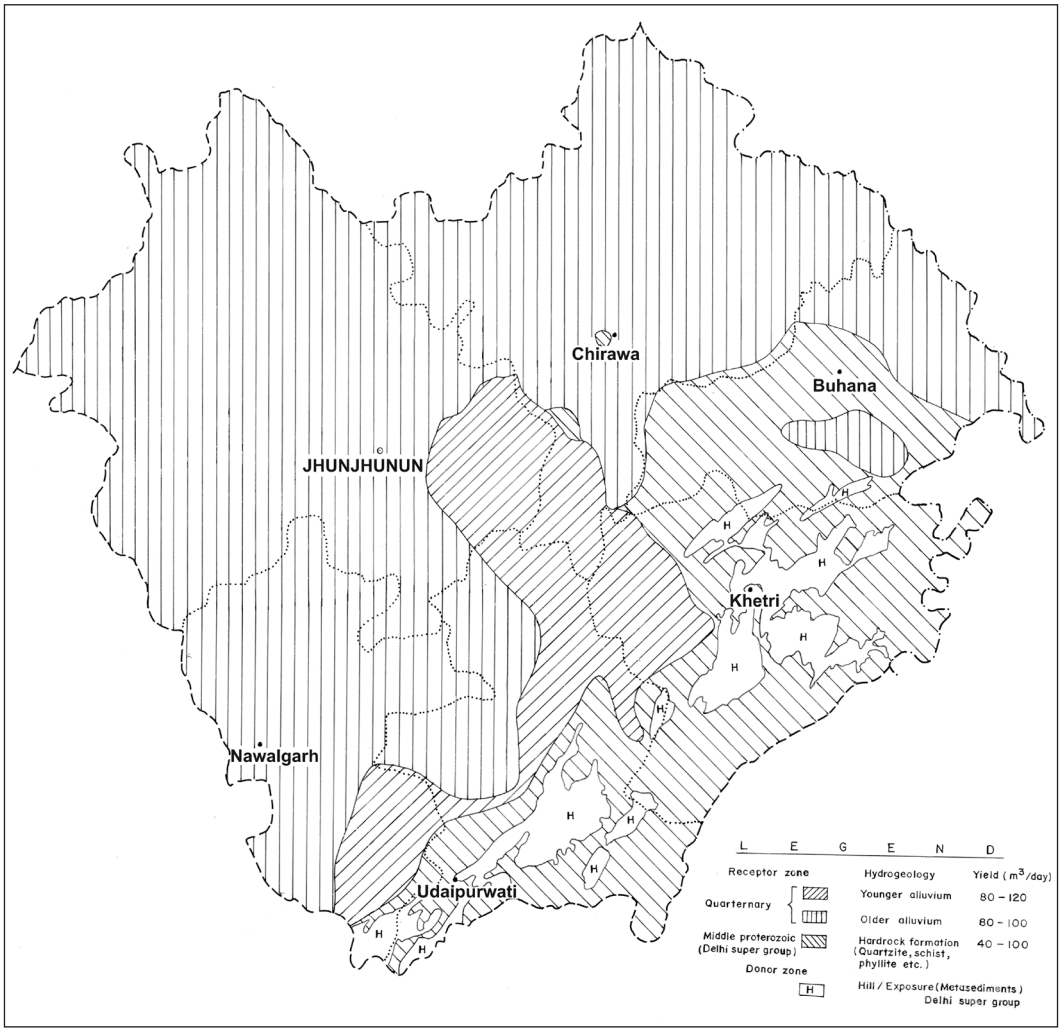

Fig. 3. Hydrogeology of Jhunjhunun district.

tehsil) and 198.12 m bgl (Bagoli, Udaipurwati tehsil), respectively, with an average depth of 60.55 m bgl (Fig. 4).

Mean depth to water is about 1.4 times more in older alluvium and 1.9 times in Metamorphic rock formation as compared to that in younger alluvium where the mean depth to water is 40.63 m bgl. The deepest mean water level was found in Buhana tehsil (86.23 m bgl), and the shallowest in Nawalgarh tehsil (50.16 m bgl).

Table 3. Area under different EC range in Jhunjhunun district

Tehsil	Area in km^2			
	EC <2.0 dS m^{-1}	EC 2.0-4.0 dS m^{-1}	EC 4.0-6.0 dS m^{-1}	EC >6.0 dS m^{-1}
Jhunjhunun	370.5 (6.62)#	757.2 (13.53)	281.8 (5.03)	213.00 (3.81)
Chirawa	1068.0 (19.08)	220.6 (3.94)	6.3 (0.11)	6.30 (0.11)
Nawalgarh	668.3 (11.94)	-	-	-
Udaipurwati	726.2 (12.97)	-	-	-
Buhana	346.1 (6.18)	192.9 (3.45)	83.3 (1.49)	18.75 (0.33)
Khetri	546.9 (9.77)	84.8 (1.52)	6.3 (0.11)	-
Total	3726.0 (66.57)	1255.5 (22.43)	377.7 (6.75)	238.05 (4.25)

Figures in parenthesis indicate percentage of total aquifer area of the district.

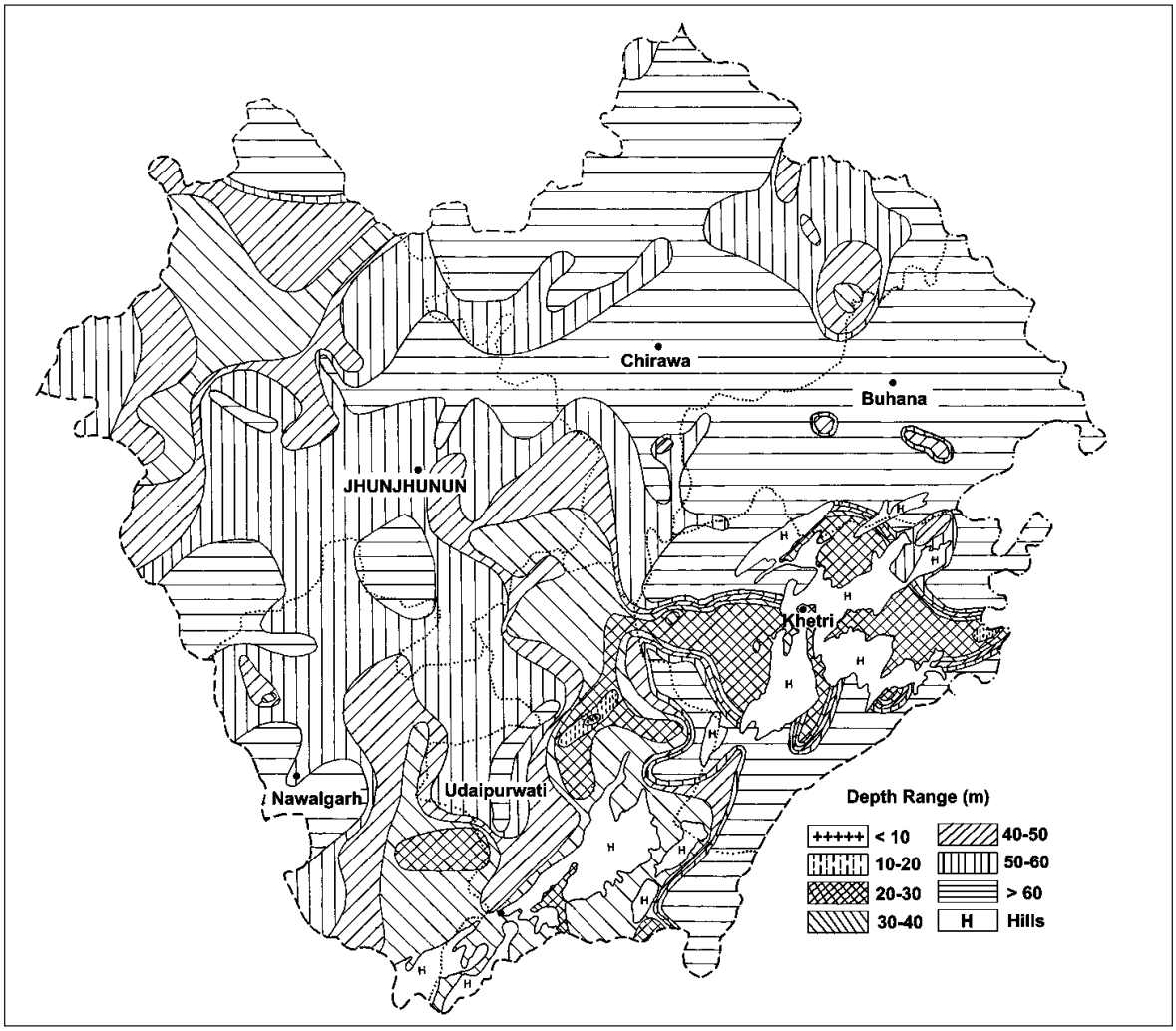

Fig. 4. Depth of groundwater table in Jhunjhunun district.

Well yield

The discharge from wells in the district is highly variable, particularly in the Metamorphic formations(i.e., 0 to 120 m^3 day^{-1}), and may be attributed to high rates of withdrawal, basement highs, and non-availability of weathered and fractured zones at depth in the hard rock areas. Under favorable conditions discharge from the wells is 40-120 m^3 day^{-1}. Sharp decline in the water table has led to many villages running out of water. The groundwater level was found stable only at one location, i.e. Basai

Table 4. Hydro-chemical summary of Jhunjhunun district

Tehsil	EC (dS m^{-1})			SAR			Na (%)			RSC (Me L^{-1})			Irrigation class
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	
Jhunjhunun	0.78	12.44	3.41	3.12	45.52	21.02	56.42	97.14	62.43	nil	18.96	7.51	C2S3R2
Chirawa	0.63	6.23	1.63	2.46	28.36	11.60	50.30	94.24	82.10	0.69	16.96	5.30	C1S2R2
Nawalgarh	0.40	1.75	0.95	2.29	19.46	9.96	59.51	93.18	69.01	0.52	7.00	3.44	C1S1R2
Udaipurwati	0.36	2.00	0.77	0.67	14.65	3.61	17.14	90.00	57.11	nil	3.96	1.53	C1S1R1
Buhana	0.47	9.60	2.17	2.46	45.84	14.84	46.41	95.64	81.11	nil	8.38	2.60	C1S2R2
Khetri	0.32	5.11	1.48	0.61	12.34	3.98	20.54	80.23	50.16	nil	1.12	0.10	C1S1R1
Overall	0.32	12.44	1.88	0.61	45.84	11.71	17.14	97.14	74.80	Nil	18.96	3.87	C1S2R2

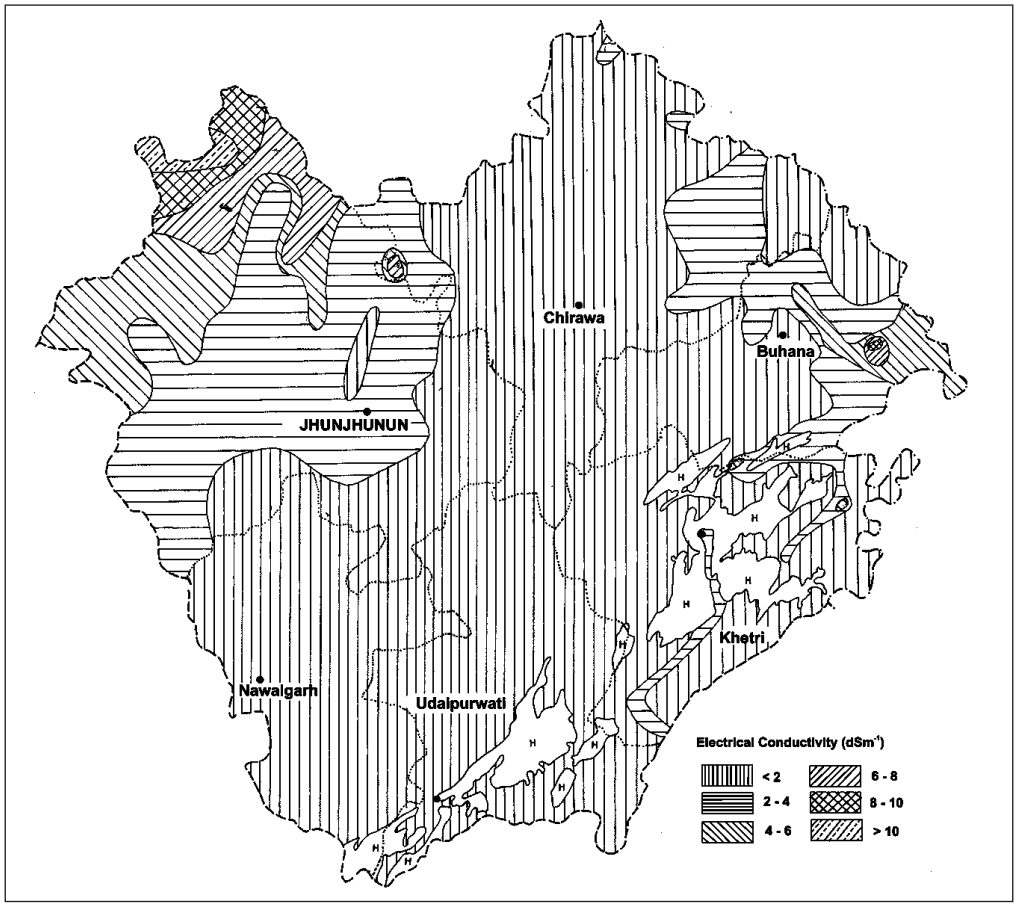

Fig. 5. Groundwater quality of Jhunjhunun district.

(Khetri tehsil), which lies in the flood plain of River Chandrawati. The rate of depletion in rest of the area varied from 0.09 to 3.81 m y^{-1} (mean 1.46 m y^{-1}) during 2001-2006. Very high rates of depletion (7-15 m y^{-1}) were found in villages Sephraguar, Sior, Mewara and Dudwa in Khetri tehsil and Lambijat and Kuthaniya in Buhana tehsil. The average depletion rate in younger alluvium, older alluvium and in Metamorphic formation is 1.20, 1.69 and 2.63 m y^{-1}, respectively.

Groundwater potential

Groundwater utilization in the district has tremendously increased during last two decades, especially to meet the water requirement for domestic and irrigation purposes. Based on the methodology of Ground Water Resource Estimation Committee (GEC, 1997), the total draft of groundwater in 2005 was estimated as 525.83 mcm, and the compounded growth rate in the groundwater use per year between 1988 and 2005 as 5.46%. During the above period the net irrigated area by wells increased from 62585 to 215858 ha and the number of wells increased from 31380 to 44968. The net recharge was more or less constant at 274.65 mcm, which meant a negative net groundwater balance of (-)251.18 mcm. The stage of groundwater development during 2005 was 191.45%. The possibility of future groundwater development in the district is therefore, almost nil.

Quality of groundwater

Groundwater in the district is largely good (mean EC <2.0 dS m^{-1}), but the quality in the northern part of the Jhunjhunun tehsil and in the eastern margin of Buhana tehsil is brackish to saline. Entire Udaipurwati tehsil and in western part of Khetri tehsil, which include the flood plains of Kantli River, have mean groundwater EC of <1.0 dS m^{-1} (Table 3).

The minimum and maximum EC values in Younger Alluvium aquifer were 0.32 dS m^{-1} (Tal-ki-dhani, Khetri tehsil) and 2.04 dS m^{-1} (Jaipahari, Chirawa tehsil), respectively (mean EC 0.88 dS m^{-1}). The mean EC in older alluvium

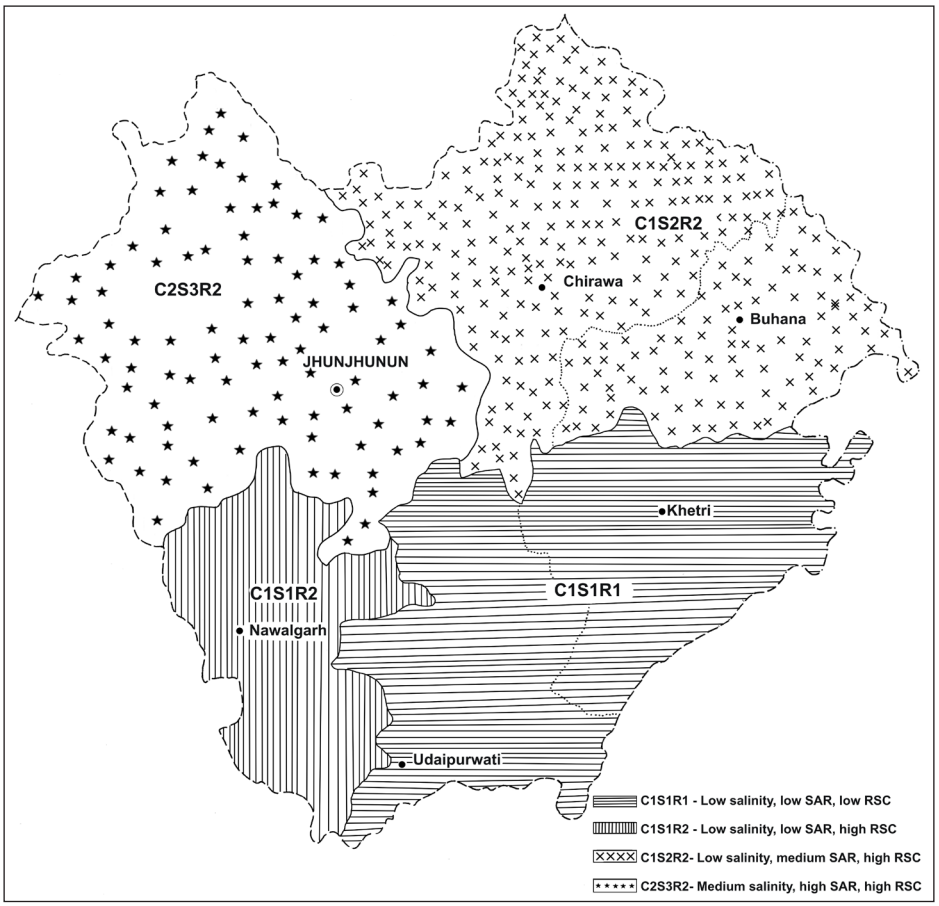

Fig. 6. Irrigation quality of groundwater in Jhunjhunun district.

and metamorphic aquifer is 2.24 and 1.66 dS m^{-1} , respectively. Udaipurwati tehsil contains the best water in the district (mean EC 0.77 dS m^{-1}). Groundwater in Chirawa, Nawalgarh and Khetri is also good (mean in the range of range of 1-2 dS m^{-1} (Fig. 5). Water in the Buhana and Jhunjhunun tehsils is brackish (EC 2-4 dS m^{-1}). In general, water quality deteriorates towards north-western part of the district.

Majority of the samples (76%) showed SAR <18 out of which 60% had SAR <10, thus indicating low to moderate sodicity in large parts. About 77% samples had sodium (Na) percentage >60 and 53% samples had RSC >2.5 me L^{-1}. High Na content and alkalinity are the major concerns for the district. By and large the younger alluvium and Metamorphic are better with low salinity, low sodium and low alkaline water (C1S1R1). Water in the older alluvium has generally low salinity, medium sodium and high alkaline water (C1S2R2). The district as a whole may be categorized as having low salinity, medium sodic and high alkaline ground water (C1S2R2). Hydro-chemical summary of the district is summarized in Table 4.

Classification of saline-sodic zones

The continuous use of groundwater with high RSC and SAR for irrigation leads to soil degradation and reduction in crop productivity. Joshi and Dhir (1989) observed that the continuous use of the water having RSC more than 15 me L^{-1} for 8-10 years on sandy soils in Barmer district had turned the soil completely barren. 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 inspite of certain limitations (Manchanda *et. al.,* 1984; Minhas and Bajwa, 2001; Gupta, 1991). In the present study saline-sodic classification has worked out as an irrigation class of groundwater, considering the above chemical constituents. Following four saline-sodic zones could be recognized in the district (Fig. 6).

C1S1R1: Low salinity, low SAR and low RSC water. Such water occurs in Udaipurwati and Khetri tehsils covering an area of 1653.2 km^2. In these tehsils average EC is <1.5 dS m^{-1}, SAR is <4.0 and RSC is <1.60 me L^{-1}. Thus, the groundwater is classified as of good quality, suitable for irrigated agriculture on sustainable basis.

C1S1R2: Low salinity, low SAR and high RSC water. This is available in Nawalgarh tehsil, covering 685.5 km^2 area. The average EC is <1.0 dS m^{-1}, SAR is <10.0 but RSC is high, with an average of 3.44 me L^{-1}. Alkaline condition may develop in soil with prolonged use of groundwater.

C1S2R2: Low salinity, medium SAR and high RSC water. This type of water has both SAR and RSC problems, and occurs in Chirawa and Buhana tehsils (1954.3 km^2). Due to the medium SAR and high RSC the groundwater in the area has potential to develop sodicity hazard in the soil. In many locations the SAR is >10.0 and RSC reaches up to 16.96 me L^{-1}. The RSC of 82% waters is >2.5 me L^{-1}.

C2S3R2: Medium salinity, high SAR and high RSC water. This water is found in Jhunjhunun tehsil, covering an area of 1622.5 km^2. Average EC of water is 3.41 dS m^{-1}, SAR is 21.02 and RSC is 7.51 me L^{-1}. High SAR (>18.0) is reflected in 65% of the samples, while 82% samples have RSC >2.5 me L^{-1}. Sodicity hazard is likely to develop in the soil soon if irrigated with this water without proper amendments.

Conclusions

The study reveals that groundwater table in most part of Jhunjhunun district is generally deep to very deep, with an average depth of 60.5 m bgl, and is declining at an alarming rate of 1.46 m y^{-1}. Due to negative groundwater balance (-251.17 mcm), the stage of groundwater development (191.45%) has exceeded the safer limit, and hence, possibility of future groundwater development is negligible. Groundwater quality is largely good with an average EC of <2.0 dS m^{-1}. However, the quality in northwestern part of the district is brackish to saline. The average SAR value in the district is >10, suggesting low to moderate sodicity in major part. Sodium percentage and RSC is normally on higher side, except in Khetri and Udaipurwati tehsils. Younger Alluvium and Metamorphic formation yield the best quality water of low salinity, low sodium and low alkalinity (C1S1R1). Higher SAR and RSC values elsewhere need to be factored while irrigation. The types of crops need also to be planned on the basis of water availability and quality.

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References

Aggarwal, R.P. and Ramamoorthy, B. 1974. Evaluation of quality of irrigation water in different soils. *Annals of Arid Zone* 13: 309-315.

Dhir, R.P. 1977. Saline waters: Their potentiality as a source of irrigation. In *Desertification and Its Control,* ICAR, New Delhi, pp. 130-138.

GEC 1997. *Report of the Groundwater Resources Estimation Committee*. Ministry of Water Resources, Government of India, New Delhi, June 1997, pp. 107.

Gupta, I.C. 1979. Use of saline water in agriculture in arid and semi-arid zones of India. Oxford and IBH Publication Co. New Delhi, pp. 40-47.

Gupta, S.C. 1991. Quality classification of groundwater of western Rajasthan. *Annals of Arid Zone* 30(4): 315-321.

Joshi, D.C. and Dhir, R.P. 1989. Management of loamy sand soils irrigated with high RSC waters. *International Symposium on Managing Sandy Soils*. Abstract Vol. II, pp. 474-475.

Manchanda, H.R., Garg, R.H., Sharma, S.K. and Singh, S.P. 1984. Effect of continuous use of sodium and bicarbonate rich irrigation water with gypsum and FYM on soil properties and the yield of wheat in a fine loamy soil. *Journal of Indian Society of Soil Science* 33: 876-883.

Minhas, P.S. and Bajwa, M.S. 2001. Use and management of poor quality waters in rice-wheat production system. *Journal of Crop Production* 4: 273-306.

Richards, L.A. 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. USDA Handbook 60, P.60.