

Groundwater Hydrochemistry of Jayal Block of Nagaur District, Central Part of Rajasthan, India

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Abstract

Rajasthan, the biggest state of the country has great reverence for water. Due to arid to semi – arid climatic conditions and scarcity of surface water resources, inhabitants are dependent largely on groundwater for drinking, agriculture and industrial purposes besides monsoon rain. There are very limited resources of groundwater in Rajasthan because of its unfavorable hydrogeological and meteorological conditions. The available groundwater has impurities like fluoride nitrate, chloride; sulphate and total dissolved solid [T.D.S.] etc.

Nagaur district falls in central part of Rajasthan and covers an area of 17718sq. kms. Total study area of the Jayal block, which lies in northern part of Nagaur district is 1948.08 sq. Kms. The discovery of lignite deposits at Kasnau, Igyar and Matasukh villages of Jayal block of Nagaur district administrative jurisdiction is a boom for the western Rajasthan. The Jayal block is located adjacent to Nagaur block and towards east of Nagaur town.

Water harvesting in the Thar Desert region of western Rajasthan got utmost attention since long back due to low and erratic rainfall pattern and high evaporation. Drought in this part is a frequent phenomenon occurs once in two years therefore inhabitants are compelled to store water by adopting various traditional water harvesting schemes. Important viable water harvesting systems practiced in this part are Talab, Nadi, Tanka, Khadin, Bawari, Jhalara, Percolation tanks and Pits, Check dams, Anne- cuts, and Roof water harvesting techniques. Roof top rainwater harvesting in the study area offers a good source of drinking water. Looking to the hydrochemistry of the groundwater of Jayal block of Nagaur district; the long term solution for potable drinking water and irrigation, Canal will be the next alternative in near future. Application of remote sensing and geographic information system (GIS) can be used for better management schemes in the study area.

Keywords: Groundwater, Hydrochemistry, Jayal Block, Nagaur District, Rajasthan.

Introduction

Nagaur district falls in central part of Rajasthan and covers an area of 17718sq. kms. and lies between 26° 23' 35" to 27° 42' 16" north latitude and 73° 04' 32" to 75° 21' 39" east longitude. Well-developed drainage is lacking and mostly the area is having internal drainage system. Luni is the only major river flowing only 37 km in the southeastern part of the district.

Total study area of the Jayal block, which lies in northern part of Nagaur district is 1948.08 sq. Kms. The discovery of lignite deposits at Kasnau, Igyar and Matasukh villages of Jayal block of Nagaur district administrative jurisdiction is a boom for the western Rajasthan. No prominent drainage system exists in and around the deposit area.

Detailed Hydrogeological investigations of the Jayal block of Nagaur district were carried out by extensive hydrogeological survey. Important key wells were selected on the basis of hydrogeological formation and quality of groundwater which cover entire area and represent various aquifers of the block. The Jayal block is located adjacent to Nagaur block and towards east of Nagaur town. Groundwater potential area of Jayal block of Nagaur district is 1724.58 sq. kms.

Aim of the Study

Rajasthan forms northwestern part of the Indian Shield and contains rock sequences ranging in age from Archaean to Holocene.

Nagaur district located in central part of the State, geologically also show variety of rock types comprises rock formations ranging in age from the Archaean basement to the recent alluvium and wind blown desert sands of the great Thar Desert. The rainfall in the district is scanty (average 450 mm per annum), and surface run off is insignificant. Hence, there is a need for comprehensive analysis of the state's groundwater resources. Groundwater development of the study area requires extensive investigations for its occurrence, estimations of its sustained yield, determination of its quality and quantity, utilization, problems involved in the proper utilization of groundwater and management practice.

The aim of the study is to aware people of the study area about sustainable development of groundwater resources and to develop suitable management schemes by using Remote Sensing and GIS technologies. The present work is an attempt to study hydrochemistry aspects of ground water of Jayal block of Nagaur district, Rajasthan.

Hydrogeology and Hydrochemistry

Six major aquifers demarcated in the district include Pre – Aravalli gneisses and metasediments, Jodhpur Sandstone, Bilara Limestone, Nagaur Sandstone, Tertiary formations and Quaternary formations. Depth to water in these aquifers varies from < 5 meters to > 80 meters below ground level. Groundwater movement in the district is in southeast to northwest direction. Depth to water generally increases towards western part of the district. Groundwater movement is in south – east to northwest direction (Gouran and Vyas, 1998). Fluoride's presence in groundwater has drawn attention of society, due to its impact on human physiology (Vyas, et al. ,2006).

The main hydrogeological formations of Jayal blocks are older alluvium, Tertiary sandstone, Nagaur sandstone and Bilara limestone. Based on the chemical quality and availability of groundwater in different formations seven Potential zones have been identified in the Jayal block. The depth to water in these zones varies from 28 to 55 meters below ground level. In few Potential zones groundwater quality is moderately saline. The depth to water in these zones varies from 35 to 70 meters below water level. The aquifer Bilara limestone has been divided into two potential zones in which the groundwater quality is ranging from potable with EC below 4000 micro-siemens/cm to moderately saline ranging from 4000-8000 micro-siemens/cm. The depth to water in these zones varies from 17 to 66 meters below ground level. The potential zone comprising of Tertiary sandstone have potable groundwater quality in the study area. This is the productive zone in the block. The depth to water in this zone ranges from 28 to 55 meters. Groundwater of the Study area of Jayal block has salinity problem. Groundwater in Jayal block is alkaline in pH (7.8 to 8.08) and their total hardness varies from 250 -2600 ppm. Nitrate concentration in groundwater ranges from 7 to 886 ppm. Fluoride concentration in groundwater ranges from 0.4 to 7.22 mg/l. whereas values of T. D. S.

ranges between 740 to 11400 ppm in Jayal block (Bhoora Ram, 2011).

Groundwater Quality of Jayal Block

On the basis of hydrogeological formations which cover study area and represent various aquifers; total 100 water samples were collected from different villages to study the groundwater quality of Jayal Block. Water samples from different sources (dug-well, dug-cum-bore well, tube well etc.) are collected during Premonsoon - 2008 (in the month of may/June) period. The physio-chemical characteristics were determined. Statistics presented are the aggregate of facts and are numerically expressed; collected in a systematic manner for pre-determined purpose and in relation to each other. The reasonable standard of accuracy maintained in statistics.

Most of the Groundwater samples of Jayal block show concentration of fluoride, nitrate, sulphates, chlorides and total dissolved solids much higher than the limit prescribed by the Bureau of Indian Standards (1992). Groundwater in Jayal block is alkaline. pH value of groundwater samples ranges from 7.11 (Ghugharyali) to 8.08 (Jaanwas) and their total hardness varies from 250 ppm (Jaanwas) to 2600 ppm (Dugoli) (Bhoora Ram , 2011).

As per Bureau of Indian Standards (1992), drinking water should not contain nitrates more than 45 mg/l. In the absence of alternative source, this limit in emergency could be raised up to 100 mg/l. If nitrates exceed 100 mg /litre in drinking water, it may cause disease Methaemoglobinmia commonly called as "Blue babies" in children and infants. The hydrogeological investigation carried out during Pre-Monsoon, 2008 in the Jayal block, it was observed that out of the total 25 surveyed villages, Nitrate concentration in groundwater within desirable limit lies only in six villages. All other samples show nitrate in the groundwater exceeding 45mg /litre. Out of the total 25 villages surveyed in the block. 76.00% villages (total 19) were found to have groundwater with nitrate contents exceeding the prescribed permissible limit. Over all 44%(11 Villages) samples in the block have nitrates in the ground water exceeding the emergency limit i.e 100 mg/litre. Nitrate concentration in ground water ranges from 7 pp, (Kasari) to 886 ppm (Dugoli) (Bhoora Ram, 2011) (Table – 1.1).

Fluorine occurs in the form of calcium fluoride (CaF₂) in the ground water. Fluoride concentration in ground water beyond the permissible limit is quite harmful to the health. Hydrogeological investigation has shown that there are many villages in the Jayal block where fluoride content in the groundwater is exorbitantly high. Out of the total 25 villages surveyed in the block 92.00% villages (total 23) were found to have groundwater with fluoride content exceeding the prescribed permissible limit. Groundwater in 60.00% (15) villages has fluoride content ranging between 1.6 to 3.00 mg/l. About 16.00% (4) villages have fluoride in the groundwater ranging between more than 3 to 8.00 mg/l. Fluoride concentration in groundwater

ranges from 0.40 ppm (Dhehroli) to 7.22 ppm (Dugoli) (Bhoora Ram , 2011) (Table – 1.1).

As per Bureau of Indian Standards (1992), drinking water should not contain total dissolved solids (T.D.S.) more than 500 mg/l but in the absence of alternative source, this limit in emergency could be relaxed up to 2000 mg/l. Results of chemical that of the groundwater samples of the Jayal block show that all 25 villages surveyed have T.D.S. more than 500mg/l. Over all 56.00% (14 villages) samples in the block have T.D.S. in the groundwater exceeding the emergency limit i.e. 2000 mg/litre. Values of T.D.S. ranges between 740 ppm (Burdi) to 8990 ppm (Matasukh) in Jayal block (Bhoora Ram , 2011) (Table – 1.1).

As per Bureau of Indian Standards (1992), drinking water should not contain sulphates more than 200 mg/l. in the absence of alternative source, this limit in emergency could be raised up to 440 mg/l. The hydrogeological investigation carried out during Pre-Monsoon, 2008 in the Jayal block, it was observed that out of total 21 surveyed villages, 71% villages (total 15) were found to have groundwater with sulphates content exceeding the prescribed permissible limit. Sulphates concentration in ground water within desirable limit lies in 08 villages. Sulphates in the ground water ; exceeding the emergency limit i. e. (400 mg/litre and above) recorded in 07 villages. Sulphates concentration as high as 1182 ppm in groundwater; recorded at Mundi (Bhoora Ram, 2011) (Table – 1.2).

The Bureau of Indian Standards (1992) suggested chlorides in drinking water to the extent of 250 mg/l in general and up to 1000 mg/l in emergency to be good for the human health. Its higher concentration affects the taste and palatability. Chemical analysis of samples collected from 21 villages of the Jayal block has shown that about 81% villages (total 17) in the block have chlorides in the groundwater more than 250 mg/l. Chlorides concentration in groundwater ranges from 128 ppm (Talniau) to 5460 ppm (Bhawla) (Bhoora Ram , 2011) (Table – 1.2).

Pande et al. (2010) reported a prominent NE — SW trending anomalous uranium hydrogeochemical zone in Didwana — Kathoti (in Jayal block) — Ladnun area of Nagaur district. Chemical analysis of groundwater samples from different villages representing Jayal block (Pre-Monsoon, 2008) are given in Table - 1.1 and 1.2.

Discussion

High concentration of dissolved salts, nitrate and fluoride are major quality problems associated with groundwater in Nagaur district of Rajasthan. Groundwater quality varies widely in the district. Potable water is available mainly in western part of Mundwa, eastern part of Riyan, Parbatsar and Didwana blocks. Potable water is also available in part of Ladnun, Merta, Jayal and Nagaur blocks. Only 37 % water sources in the district fall within the drinking limits of the total dissolved solids i.e. 1500 mg/l. The remaining have high T.D.S. and generally not suitable for drinking water supply. It is saline in western part of Nagaur, northern part of Jayal,

southern part of Kuchhaman and northern and central parts of Degana blocks. Beside, pockets of saline groundwater are scattered throughout the district. (Maanju et al., 2003). Salinity of groundwater in the district varies widely; Degana, Didwana, Jayal, Ladnun, Makrana and Nagaur blocks in the district are most affected by salinity problem (Gouran and Vyas, 1998; Vyas,A., 1999). The minimum and maximum values of salinity have been observed to be 250 micro-siemens/cm at village Sarangwas (Merta block) and 32000 micro-siemens/cm at village Jaswantgarh (Ladnun block).

The effects of high fluoride concentration in groundwater in Nagaur district of Rajasthan, are very severe. About 64% villages of the Nagaur district are endemic to fluoride related problems. The fluoride concentration in the district ranges from less than 1ppm to 90 ppm and high fluoride concentration in the groundwater causing fluorosis problem (Vyas, A., 2015). Acute toxicity of fluoride is observed in Makrana, Degana, Ladnun, Jayal and Nagaur block where percentage of groundwater having fluoride above the permissible level of 2 ppm varies from 49 to 65 %. High concentration of fluoride creates health hazards in parts of Nagaur, Jayal, Ladnun, Didwana, Makrana and Degana blocks of the district.

Excessive nitrate in groundwater creates problem in Nagaur, Jayal, Ladnun, Didwana, Makrana and Degana blocks. Hardness in groundwater is more in Nagaur, Jayal and Ladnun blocks of the district (Gouran and Vyas, 1998; Vyas and Paliwal, 2001; Gaur and Vyas, 2007). As much as 4750 mg/l of nitrate and 90 mg/l of fluoride has been observed in the groundwater which are perhaps the maximum values observed in the state of Rajasthan. Similarly, nitrate problem is more severe in Nagaur, Ladnun, Jayal, Degana, Didwana and Makrana blocks. In these blocks more than 50% water has been found contain nitrate more than 100 mg/l. Nearly 30% groundwater have total hardness more than 600 mg/l as calcium carbonate, the hardness in water is more in Nagaur, Ladnun and Jayal blocks (Gouran and Vyas, 1998; Vyas,1999).

Depletion of Groundwater level in the Jayal block of Nagaur district; is at an alarming rate. The average water level condition in the Jayal block also shows depleting trend with depletion of 9.94 meters for period 1984-2007. The depth to water level observed during Pre-monsoon - 2008 in Jayal block ranges from 7.65 meters to 68.40 meters. Overexploitation of groundwater resources in the block resulting in depletion of water table at alarming rate, desaturation of aquifers and deterioration in chemical quality of groundwater. Therefore study area is recommended for adoption of adequate measures for conservation and judicious management of groundwater resources. (Quereishi, J. and Vyas, A. 2008 and 2017).

Roof top rainwater harvesting in the study area offers a good source of drinking water. Viable and long term drought mitigation efforts should aim at sustaining and recharging the depleting

groundwater table by adopting various suitable rainwater harvesting and artificial recharge methods in the Jayal block of Nagaur district in Rajasthan.

For long term solution of potable drinking water Canal will be the next alternative in near future.

Table - 1.1 Groundwater Quality in Jayal Block (Pre- Monsoon, 2008) (Bhoora Ram, 2011)

S. No.	Name of Village	Aquifer	P ^H	TH	No ₃ ⁻¹	F ⁻¹	T.D.S.
1	Arwad	Tertiary Sandstone	7.65	390	62	2.8	1220
2	Barsuna	Older Alluvium	7.56	260	59	1.2	2180
3	Burdi	Bilara Limestone	7.89	280	53	5.75	740
4	Chhajoli	Nagaur Sandstone	7.99	290	20	1.05	1089
5	Deh	Bilara Limestone	7.74	350	40	2.3	1160
6	Dehari	Older Alluvium	7.28	750	35	1.78	4460
7	Dheholi	Older Alluvium	7.42	930	182	0.4	4400
8	Didiya Khurd	Bilara Limestone	7.34	740	70	2.28	4950
9	Dotina	Older Alluvium	7.65	450	162	2.75	2980
10	Dugastau	Bilara Limestone	7.25	1650	310	2.39	4150
11	Dugoli	Older Alluvium	7.82	2600	886	7.22	4300
12	Firozpora	Bilara Limestone	7.62	540	38	2.51	1388
13	Ghugharyali	Older Alluvium	7.11	1390	160	1.75	5890
14	Igyar	Tertiary Sandstone	7.61	510	180	3.6	2330
15	Jalniasar	Nagaur Sandstone	7.61	510	120	1.1	1500
16	Jaanwas	Bilara Limestone	8.08	250	85	2.95	960
17	Jayal	Nagaur Sandstone	7.49	890	140	2.97	3290
18	Kasari	Nagaur Sandstone	7.71	400	7	3.15	1300
19	Kashipura	Older Alluvium	7.52	1460	320	1.95	4970
20	Kasnau	Tertiary Sandstone	8.03	930	82	2.21	3610
21	Khatu Kalan	Nagaur Sandstone	7.86	350	88	2.18	945
22	Khiala	Bilara Limestone	7.56	550	177	3.41	1750
23	Matasukh	Older Alluvium	7.65	1900	22	2.92	8990
24	Mitha-Manjra	Nagaur Sandstone	7.75	250	165	1.85	897
25	Uchaida	Nagaur Sandstone	7.70	720	82	0.6	1280

Note: All values are in mg/lit. or ppm, except pH

Table - 1.2 Chemical Analysis of Groundwater Samples from Jayal Block (Pre- Monsoon, 2008) (Bhoora Ram, 2011)

S.No	Village	E.C.	Ca ⁺²	Mg ⁺²	Cl ⁻¹	CO ₃ ⁻²	HCO ₃ ⁻¹	SO ₄ ⁻²
Aquifer type : Bilara Limestone								
1	BARNEL	3600	64	58	695	00	403	384
2	BODWA	1700	64	29	156	00	366	211
3	FARDOD	5970	90	27	1574	00	659	269
4	KATHOTI	3200	20	148	894	00	415	711
5	KHANWAR	6500	76	146	922	00	683	663
6	MANGLOD	5600	36	192	1418	00	366	005
7	ROL	6300	98	74	1886	00	366	163
8	SONELI	2700	40	118	234	00	500	504
Aquifer type : Tertiary Sandstone								
9	BHAWLA	16100	00	00	5460	00	00	00
10	JHUNJALA	5800	48	49	1461	00	513	615
11	KALVI	7600	84	195	1886	00	439	91
12	MUNDI	8800	116	202	1674	00	610	1182
Aquifer type : Nagaur Sandstone								
13	BOSERI	6700	305	58	1631	00	732	125
14	PINDIA	6400	46	73	1574	00	366	384
Aquifer type : Limestone (Saline)								
15	CHAPRA	19000	00	00	2907	00	00	00
16	JHARELI	1710	82	62	4042	00	488	288
Aquifer type : Older Alluvium								
17	GORAU	6700	224	340	1744	00	476	596
18	KHABRIANA	3500	40	94	156	00	464	913
19	SURPALIYA	6800	142	009	1419	00	354	264
20	TALNIYAU	1600	38	006	128	00	1013	355
21	TARNAU	16300	00	00	4964	00	00	00

Note: All values are in mg/lit., except E.C. in micro Siemens /cm.

**Table - 1.3 Distribution of Excessive Radicals in Groundwater of Jayal Block (Pre- Monsoon, 2008)
(Bhoora Ram , 2011)**

Percentage of Villages with Excess Value (in mg/lit)				
Block	Nitrate > 45	Sulphate > 200	Chloride > 250	TDS > 500
Jayal	76 % (25)	71 % (21)	81 % (21)	100 % (25)

(No. of villages sampled are given in under Bracket)

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Figure- 1 Location Map of the study Area

