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

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Abstract

Groundwater the natural gift to the inhabitants living on this mother planet, is a precious and the most widely resource of the earth. This resource is of utmost importance for survival of life, lies beneath the ground surface. Due to unfavorable Hydrogeological and meteorological conditions groundwater resources are limited in Rajasthan state. Nagaur district falls in central part of Rajasthan and covers an area of 17718 sq. kms. and lies between 26° 23′ 35′′ to 27° 42′ 16′′ north latitude and 73° 04′ 32′′ to 75° 21′ 39′′ east longitude. The district experiences an arid to semi arid type of climate. The rainfall is scanty (average 450 mm per annum), and surface run off is insignificant. Well-developed drainage is lacking and mostly the area is having internal drainage system. The study area of Didwana block of the Nagaur district lying in the northeastern part of the district covers about 1637.59 sq.kms area. Saline patches covering large tracts, occur in Didwana block. Groundwater quality and Depth to water varies considerably in the block. 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.

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

Introduction

Of the total global water resources, about 97.2 % is salt water, mainly in oceans and only 2.8 % is available as fresh water. Out of this about 2.2 % is available as surface water and remaining 0.6 % as ground water. From 0.6 % of stored ground water, only about 0.3 % (41.1 x 104 M ha-m.) can be economically extracted with the present drilling technology, the remaining 0.3 % being unavailable as it is lying below a depth of 800 meters (Raghunath, 1987). 33 % of the country reels under drought and 13 % are recognize as flood prone zone suggesting 46 % of the land is not worth. 75 % of the rainfall over the country is concentrated over the June-September period (South-West monsoon), which shows most uneven distribution of rainfall.

Geologically, Nagaur district has a wide spectrum of rock formations i.e. the Archaean basement rocks to the recent alluvial and desert sands of great Thar Desert. Six major aquifers demarcated in the district. Depth to water in these aquifers varies from 3 meters to 80 meters below ground level. Groundwater movement is in southeast to northwest direction. Fluoride's presence in groundwater has drawn attention of society, due to its impact on human physiology. Arid to semi-arid climate, low, and erratic rainfall, absence of surface water resources, recurrent famines and lowering of the water table aggravates the miseries of inhabitants. 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).

The study area of Didwana block lying in the northeastern part of the Nagaur district (Figure - 1.1) and bounded on north and northwest by Ladnun block of Nagaur district, on south by Makrana block of Nagaur district, southeast by Kuchhaman block of Nagaur district, on west by Jayal block of Nagaur district and on the east by Sikar district of Rajasthan. Didwana block lies between 27° 04' 50" and 27° 30' 29" North latitudes and 74° 19' 46" and 74° 50' 34" east longitudes. Didwana town (Head quarter of the Panchayat Samiti), is situated at a distance of 98 kilometers east of district head quarter, Nagaur and 200 kilometers to the north-west to the Jaipur. Didwana is connected with district headquarter by road only.

Degana - Ratangarh Broad gauge railway line (recently completed under gauge conversion) passes through Didwana. Didwana is famous for salt lake producing salt from brine in the lake region. Arid to Semi Arid climatic conditions prevailing in the study area of Didwana block. The rainfall is scanty and erratic. Scarcity of water resources in the study area compels the inhabitants to use water resources without considering the quality of water.

Aim of The Study

India is one of the wettest countries in the world in terms of average annual rainfall, yet there are problems of distribution of surface water, both spatially and temporally with wide variations. Hence, there is a need for comprehensive analysis of the country's groundwater resources. Development of groundwater in an 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 present work is an attempt to study hydrochemistry aspects of ground water, which are significant not only in the analysis parlance but also in the field of planning and management.

Therefore aim of the study is to aware inhabitants about sustainable development of groundwater resources in the study area and to develop suitable management schemes by using Remote Sensing and GIS technologies.

Geology, Hydrogeology and Hydrochemistry

Geologically, Nagaur district comprises wide spectrum of rock formations ranging in age from the Archaean basement rocks to the Recent alluvium and desert sands of the great Thar Desert (Paliwal, 1999a). Groundwater, the important resource for mankind, depends on physiography, climate and geology. Six major aquifers demarcated in the Nagaur district include Older alluvium, Tertiary sandstone, Nagaur sandstone, Bilara limestone, Jodhpur sandstone and Precambrian metamorphics (Granite/Gneisses, Schists and Phyllites). Depth to water generally increases towards western part of the district. Groundwater movement is in south – east to northwest direction (Gouran and Vyas, 1998). Older alluvium, Jodhpur Sandstone and Schist, Phyllites, Granite /Gneiss are hydrogeological formations demarcated in the Didwana block. Groundwater generally occurs under water table conditions in alluvium and schist but semi confined to confine in sandstone due to presence of overlying argillaceous beds. Depth to water varies considerably in the study area (Vyas A., 1999, 2015; Vyas, A. and Paliwal, B. S., 2001; Vyas, etal.2006).

Older alluvium in the Didwana block occurs in the central and southeastern parts and covers an area of 1089.75 sq Kms. Depth to water ranges from 10 to 50 meters below ground level in this aquifer. Yield of wells and tube wells from these aquifers varies from 36 to 250 M^3/day and groundwater associated with these resources having electrical conductivity less than 4000 micro - siemens /cm. at 25° C. In Jodhpur sandstone depth to water ranges from 12 to 35 meters below ground level. It is located in the southwestern part of the block and covers an area of 62.50 sq Kms. The discharge of wells and tube wells varies from 18 to 300 M^3 / day and the groundwater quality is potable having electrical conductivity value less than 4000 micro- siemens /cm. at 25° C. Other water bearing formation schist that is less productive located in the north–western part of the Didwana block and covers an area of 485.34 sq Kms. The depth to water ranges from 10 to 35 m b.g.l. The discharge of wells and tube wells varies from 18 to 150 M^3 / day the groundwater quality is potable having electrical conductivity value less than 4000 micro- siemens /cm. at 25°C. In these aquifers groundwater is available only in weathered zone and yield from these is low to moderate (Gouran and Vyas, 1998; Vyas, etal.2006).

Chemical analysis reveals that groundwater quality varies widely in the Didwana block and high concentration of dissolved salts; nitrate and fluoride are major quality problems associated with groundwater in the study area. 40% groundwater of the Didwana block has more than 1500 mg/lit. of T.D.S (Total number of 30 villages of the Didwana block surveyed) and therefore not suitable for drinking water supply. 38% groundwater of this block has more than 100 mg /lit of nitrate (Total number of 29 villages of the Didwana block surveyed). Acute toxicity of fluoride is observed in Didwana block. 56% groundwater of this block has 1.7 mg /lit and above of fluoride (Total number of 152 villages of the Didwana block surveyed). 74 % groundwater of this block has more than 200 mg /lit of chloride (Total number of 152 villages of the Didwana block surveyed). About 40% groundwater of this block have more than 200 mg /lit of sulphate (Total number of 122 villages of the Didwana block surveyed). Intake of excessive fluoride, nitrate, sulphate, chloride, and T.D.S. through groundwater causes some health problems (Paliwal, 1999b).

Groundwater Quality of Didwana Block

To study the groundwater quality of Didwana Block total 94 water samples were collected from different 57 villages on the basis of hydrogeological formation which cover entire study area and represent various aquifers. Water samples from different sources (dug-well, dug-cum-bore well, tube well etc.) are collected during Pre-monsoon - 2008 (in the month of May/June) period. The physio-chemical characteristics were determined according to the analytical procedure. 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 Didwana 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 Didwana block are alkaline. pH value of groundwater samples ranges from 7.26 (Madam) to 8.65 (CHHAPARI KALAN) and their total hardness varies from 100 ppm (KHURI) to 1600 ppm (SINGHANA) (Chaudhary, R., 2010).

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 Didwana block, it was observed that out of the total 57 surveyed villages, Nitrate concentration in groundwater within desirable limit lies only in six villages. All other samples show nitrate in the groundwater exceeding 45 mg /litre. Over all 56.14% (32 villages) samples in the block have nitrates in the groundwater exceeding the emergency limit i.e.100 mg /litre. Nitrate concentration in groundwater ranges from 10 ppm (Aakoda) to 490 ppm (KHURI) (Chaudhary, R , 2010) (Table – 1.1).

Fluorine occurs in the form of calcium fluoride (CaF2) in the groundwater. Fluoride concentration in groundwater beyond the permissible limit is quite harmful to the health. Hydrogeological investigation has shown that there are many villages in the Didwana block where fluoride content in the groundwater is exorbitantly high. Out of the total 57 villages surveyed in the block 47.36% (total 27) villages were found to have groundwater with fluoride content exceeding the prescribed permissible limit. Groundwater in 28.07% (16) villages has fluoride content ranging between 1.6 to 3.00 mg/l. About 14.03% (8) villages have fluoride in the groundwater ranging between more than 3 to 5.00 mg/l. Fluoride concentration in groundwater ranges from 0.30 ppm (Alakh pura) to 6.30 ppm (Loroli Kalan) (Chaudhary, R., 2010) (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 examinations of the groundwater samples of the Didwana block show that all 57 villages surveyed have T.D.S. more than 500mg/l. Over all 43.85% (25 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 540 ppm (KOLIYA) to 6310 ppm (MADAM) in Didwana block of nagaur district (Chaudhary, R., 2010) (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 400 mg/l. The hydrogeological investigations carried out during Pre-Monsoon, 2008 in the Didwana block, it was observed that out of the total 25 surveyed villages, sulphates concentration in groundwater within desirable limit lies in seventeen villages. In four villages, sulphates in the groundwater exceeding the emergency limit i.e. 400 mg /litre and above. Sulphates concentration in groundwater ranges from 0.0 ppm (BAgATPURA) to 961 ppm (DAYALPURA) (Chaudhary, R., 2010) (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 25 villages of the Didwana block has shown that about 92% villages in the block have chlorides in the groundwater more than 250 mg/l. Chlorides concentration in groundwater ranges from 71 ppm (SUPKA) to 1702 ppm (DAYALPURA) (Chaudhary, R., 2010) (Table – 1.2).

Significant uranium values are reported in carbon phyllites near Indolao ki dhani to the SSW of Didwana. Recent study indicated a uranium halo extending over 30 sq. km also encompasses the Didwana salt lake, which recorded uranium values up to 210 ppm on the western periphery of the lake. The average uranium content in samples collected from well section and from nearby well dumps, is around 60 ppm (Ramesh Kumar et al., 2009). Pande et al. (2010) reported a prominent NE – SW trending anomalous uranium hydrogeochemical zone in Didwana – Kathoti – Ladnun area of Nagaur district.

Chemical analysis of groundwater samples from different villages representing Didwana block (Pre-Monsoon, 2008) are given in Table - 1.1 and 1.2. Distribution of Excessive radicals in groundwater of Didwana block of the Nagaur district is given in Table-1.3.

Discussion

Groundwater is a diminishing resource and it's over exploitation though out the world has warrant classifying this as a SCARCE RESOURCE. Population explosion have created deep crisis in availability of these resource. Nagaur district is the most problematic district of Rajasthan state with regard to groundwater quality. High concentration of dissolved salts, nitrate and fluoride are major quality problems associated with groundwater in Nagaur district. Groundwater quality varies widely; it is saline in southern part of Kuchhaman, northern part of Jayal, northern and central parts of Degana and western part of Nagaur blocks. Beside, pockets of saline groundwater are scattered throughout 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 (Maanju et al., 2003).

Salinity of groundwater in the district varies widely; Degana, Didwana, Jayal, Ladnun, Makrana and Nagaur are affected blocks. 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). 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. Degana, Didwana, Jayal, Ladnun, Makrana and Nagaur blocks in the district are most affected by salinity problem (Gouran and Vyas, 1998; Vyas, 1999). Excessive nitrate in groundwater creates problem in Degana, Didwana, Jayal, Ladnun, Makrana and Nagaur blocks. Hardness in

groundwater is more in Jayal, Ladnun and Nagaur blocks of the district (Gouran and Vyas, 1998; Vyas and Paliwal, 2001; Gaur and Vyas, 2007). High concentration of fluoride creates health hazards in parts of Degana, Ladnun, Nagaur, Jayal, Makrana and Didwana blocks of the district. 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. Acute toxicity of fluoride is observed in Makrana, Degana, Nagaur, Ladnun and Jayal block where percentage of groundwater having fluoride above the permissible level of 2 ppm varies from 49 to 65 %. Similarly, nitrate problem is more severe in Degana, Didwana, Jayal, Ladnun, Makrana and Nagaur 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 Jayal, Ladnun and Nagaur blocks(Gouran and Vyas, 1998; Vyas,1999).

Groundwater quality and Depth to water varies considerably in Didwana block of Nagaur district. Depth to water level depleted at an alarming rate in the Didwana block due to the increased pumpage for different sectors. Frequent drought conditions, reduced precipitation and high temperature during summer further decrease natural groundwater recharge. Tremendous rate of depletion was responsible for reduced well yields in the study area. 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. Groundwater storage of depleted aquifers can be improved by adopting various suitable artificial recharge methods. Rainwater harvesting through roofs of the houses to the underground tanks for drinking purposes should be promoted in the study area. Roof top rainwater harvesting in the study area offers a good source of drinking water. Looking to the hydrochemistry of the groundwater of Didwana 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.

Table - 1.1.Groundwater Quality in Didwana Block
(Pre- Monsoon, 2008) (Chaudhary, R. , 2010)

S. No.	Name of Village	Source	P^H	TH	No_3^{-1}	F^{-1}	T.D.S.
1	Aagunta	T/W	7.35	580	121	4.51	2400
2	Aakoda	O/W	7.85	350	10	2.35	2760
3	Alakh Pura	O/W	8.27	200	65	0.3	755
4	Bagatpura	T/W	7.66	400	123	2.05	2955
5	Baldu	T/W	8.07	270	33	1.27	635
6	Bansa	TW	8.33	370	126	1.3	870
7	Banthri	O/W	7.8	350	104	2	4800
8	Bardawa	O/W	8.06	250	254	1.4	1500
9	Barangna	O/W	8.02	240	152	0.81	910
10	Bawari	O/W	8.25	250	132	0.35	860
11	Beechawa	O/W	7.9	245	440	2.32	2640
12	Bemoth	O/W	7.66	510	329	3.79	3800
13	Beri Kalan	O/W	8.44	110	28	1.73	870
14	Beri Khurd	T/W	8.25	120	138	1.61	1445
15	Bhadliya	T/W	8.15	200	43	1.04	915
16	Bhawad	O/W	7.9	175	280	2.72	2460
17	Chhapari Kalan	T/W	8.65	650	432	4.53	2230
18	Cholu Khan	T/W	7.73	910	473	1.53	3630
19	Chugni	T/W	8.41	170	97	0.92	755
20	Dabra	O/W	8.34	110	127	0.94	705
21	Dasana Kalan	O/W	7.71	760	98	1.92	2720
22	Daulatpura	O/W	7.83	250	36	0.91	780
23	Dayalpura	T/W	7.67	260	183	5.41	2760
24	Deendarpura	O/W	7.83	350	276	2.93	2360
25	Dhankoli	T/W	8.45	150	59	0.78	605
26	Didwana	T/W	7.44	390	132	1.3	1135
27	Dudoli	T/W	7.66	510	171	1.4	1585
28	Firozpura	T/W	7.96	440	121	0.64	1055
29	Fogri	O/W	7.72	270	86	2.35	2190
30	Jharod	O/W	8.17	160	123	1.06	1065
31	Kayamsar	T/W	8.15	110	98	0.73	757
32	Kerap	T/W	7.65	340	109	1.96	2565
33	Khakholi	O/W	7.85	230	76	2.87	1670
34	Kharesh	O/W	7.83	160	68	5.07	1350

35	Khojas	O/W	7.8	400	87	4.4	1440
36	Khunkhuna	O/W	7.8	1230	56	1.52	2520
37	Khuri	O/W	7.9	100	490	3.04	2646
38	Kichak	T/W	8.01	160	59	0.81	1210
39	Koliya	O/W	7.9	N/A	20	3.44	540
40	Ladriya	T/W	8.17	160	90	1.3	845
41	Lalasari	O/W	7.9	150	129	2.4	4680
42	Loroli Kalan	T/W	8.11	230	262	6.3	2565
43	Madam	T/W	7.26	1190	235	2.6	6310
44	Mamroda	T/W	7.56	410	103	1.2	3360
45	Mawa	O/W	7.8	165	64	3.2	3240
46	Molasar	O/W	8.06	170	158	0.49	750
47	Nimbi Khurad	T/W	8.1	350	104	1.2	2410
48	Nimod	T/W	8.18	140	135	0.51	810
49	Ransisar Charna	T/W	8.24	230	85	4.48	2570
50	Rasid Pura	T/W	7.72	240	67	0.53	915
51	Sardarpura Khurd	O/W	8.24	130	83	1.87	980
52	Singhana	O/W	7.9	1600	146	0.48	3120
53	Singrawat Kalan	T/W	8.05	200	98	0.7	985
54	Sudrasan	T/W	8.14	130	89	0.71	755
55	Supka	O/W	7.8	350	130	1.36	3360
56	Tarpura	O/W	7.84	230	223	2.78	1655
57	Toshina	T/W	7.77	210	63	1.49	1665

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

Table - 5.2.Chemical Analysis of Groundwater Samples from Didwana Block (Pre- Monsoon, 2008) (Chaudhary, R. , 2010)

S.No	Village	E.C.	Ca^{+2}	Mg^{+2}	Cl^{-1}	CO_3^{-2}	HCO_3^{-1}	SO_4^{-2}
Aquifer type : Older Alluvium								
1	Bagatpura	2700	22	34	752	0	818	0
2	Bansa	1900	40	61	170	0	427	96
3	Banthri	8000	40	61	1000	0	854	48
4	Bhawad	4100	10	36	355	0	842	48
5	Bichawa	4400	28	43	723	0	769	43
6	Chapri Bari	1800	20	36	333	0	683	10
7	Dabra	2500	44	58	284	0	354	653
8	Dasana	3400	20	12	858	0	647	5
9	Daulatpura	2500	20	24	397	0	1770	48
10	Dayalpura	9400	120	49	1702	0	1831	961
11	Kerap	4800	40	158	780	0	1342	706
12	Khojas	2400	78	50	362	0	976	5
13	Khunkhuna	4200	52	268	1099	0	244	269
14	Lalasari	7800	40	12	929	0	122	2
15	Laroli Kalan	1260	48	109	808	0	1879	48
16	Mawa	5400	50	10	660	0	1001	264
17	Molasar	2300	24	89	355	0	561	67
18	Nimbi Chhoti	5500	20	85	1135	0	1086	86
19	Nimod	1600	22	11	347	0	122	48
20	Ransisar Jodha	4800	80	12	886	0	854	10
21	Sudrasan	2900	56	21	496	0	549	5
Aquifer type : Schist								
22	Didwana	3200	20	61	397	0	244	432
23	Koliya	900	22	47	709	0	976	5
24	Singhana	5200	120	316	1432	0	244	384
25	Supka	5600	40	61	71	36	366	384

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

Table - 1.3 Distribution of Excessive Radicals in Groundwater of Didwana Block (Pre- Monsoon, 2008) (Chaudhary, R. , 2010)

Percentage of Villages with Excess Value (in mg/lit)				
Block	**Nitrate > 45**	**Sulphate > 200**	**Chloride > 250**	**TDS > 500**
Didwana	89.47% (57)	32% (25)	92% (25)	100% (57)

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

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Figure- 1 Location Map of The Study Area