DISTRICT GROUNDWATER BROCHURE

GOVERNMENT OF INDIA

MINISTRY OF WATER RESOURCES

CENTRAL GROUND WATER BOARD

GROUND WATER SCENARIO BHARATPUR DISTRICT RAJASTHAN

Western Region

Jaipur

2013

DISTRICT AT A GLANCE – BHARATPUR, RAJASTHAN

S No	Item	Statistics	
1	**GENERAL INFORMATION**		
	(i) Geographical area (sq km)	5066 sq. km.	
	(ii) Administrative Division (As on 31.3.2008)		
	Number of Tehsils	10	
	Number of Blocks	9	
	Number of Villages	1472	
	(iii) Population (As per 2011 Census)	25,48,462	
	(iv) Average Annual Rainfall (1977-2011) in mm	602.2mm	
2	**GEOMORPHOLOGY**		
	Major Physiographic Units	Alluvial Plains, Valley Fills, Ravines and Flood Plains	
	Major Drainage	Banganga, Gambhiri and Ruparel	
3	**LAND USE (sq km)(2010-20011)**		
	(a) Forest Area	33645 ha	
	(b) Net Sown Area	396466ha	
	(c) Cultivable Area	596919 ha	
4	**MAJOR SOIL TYPE**		
5	**AREA UNDER PRINCIPAL CROPS** (As on 2010-11)	Crops	Area in ha
		Total	346969
		Oil Seeds	206173
		Pulses	8564
		Wheat	157196
		Jowar	54932
		Bajra	122028
		Barley	2708
		Rice	1536
6	**IRRIGATION BY DIFFERENT SOURCES**		
	Source	Net Area Irrigated	Gross Area Irrigated
	Canal	2287	2362
	Tube wells	320684	323732
	Other wells	7334	7404
	Other Sources	129	129
	Total	330434	333627
7	**NUMBER OF GROUND WATER MONITORING WELLS OF CGWB** (As on 31. 03.2012)		
	Number of Dug wells	25	
	Number of Piezometers	23	

S No	Item	Statistics
8	**PREDOMINANT GEOLOGICAL FORMATIONS**	Bhilwara & Aravalli, Delhi Super group, Vindhyan Super group and Quaternary Alluvium
9	**HYDROGEOLOGY**	
	Major Water bearing formation	Quaternary Unconsolidated formation & Hard Rocks
	Depth to water level (Pre-monsoon, 2011) (mbgl)	1.6 – 24.48
	Depth to water level (Post-monsoon, 2011) (mbgl)	0.34 - 28.08
10	**GROUNDWATER EXPLORATION BY CGWB** (As on 31.3.2012)	
	Number of wells drilled (EW, OW, Total)	E W – 56 OW – 3 SH – 6 PZ – 35
	Depth Range (m)	30 – 210
	Discharge (liter per minute)	3 – 2529
	Transmissivity (m^2/day)	6 – 787
11	**GROUND WATER QUALITY**	
	Presence of chemical constituents (EC in µS/cm at 25^0 C, F in mg/l, Nitrate in mg/l)	EC - 485 - 13270 Fluoride – 0.1 – 9.42 Nitrate – 15 - 155 Iron – Negligible – 5.41
12	**DYNAMIC GROUND WATER RESOURCES (March, 2009) in mcm**	
	Annual Replenishable Ground Water Resources	495.6775
	Net Annual Groundwater Availability	453.5100
	Net Annual Ground Water Draft	508.5642
	Projected Demand for Domestic and Industrial Uses up to 2025	67.814
	Stage of Ground Water Development	112.14 %
13	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	Limited fresh water Resources, with declining groundwater trend, salinity problem and Fluoride and Iron contamination at places

Ground Water Information
Bharatpur District
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GROUND WATER SCENARIO
DISTRICT BHARATPUR, RAJASTHAN

1.0 Introduction

Bharatpur district is located between 26°40’ and 27°50’ latitude and 76°53’ and 77°45’ longitude covering an area of 5066 sq.km. The district is part of Bharatpur Division and is divided into 9 sub-divisions. Administratively the district is divided into 10 tehsils and 9 development blocks. The district has 1472 villages and 9 urban towns. As per Census 2011, total population of the district is 25,48,462 with urban and rural population at 4,95,099 and 20,53,363 respectively. Index map of the district showing block boundaries is presented as **Figure-1**.

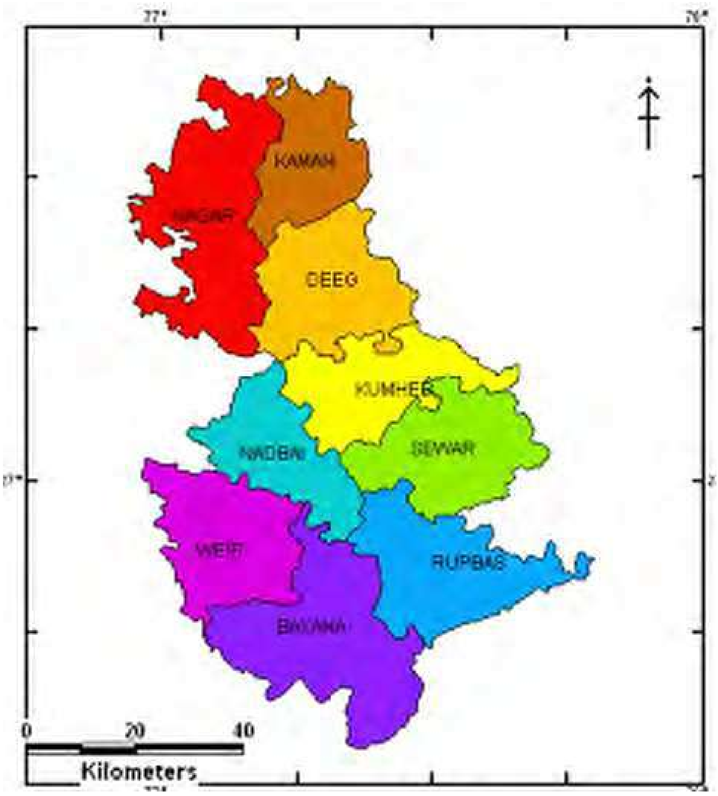

Figure 1: Administrative Divisions

Geological Survey of India had first carried out geophysical surveys in parts of Bharatpur district in the year 1950. Systematic hydrogeological survey of Banganga river basin in its lower reaches falling in Bharatpur district was carried out by Geological Survey of India during 1966-68. These surveys were later taken up by Central Ground Water Board after its inception in 1972. A list of various scientific studies carried out in the district by Central Ground Water Board is given in Table 1.

Table 1: Studies undertaken by CGWB.

S. No.	Officer	AAP	Type of Survey/Study
1.	M.Mehta & Kailash Chander	1974-75	Systematic hydrogeological surveys in Banganga river basin, Jaipur, Bharatpur, Alwar and Sawai Madhopur districts.
2.	S.K. Jain & S. Datta	1979-80 and 1980-81	Systematic hydrogeological survey in Gambhir river basin covering parts of Bharatput, Dholpurand Sawai Madhopur districts.
3.	S.K. Gupta	1994-95	Reappraisal hydrogeological survey in parts of Bharatpur district covering Kumher, Nadbai, Sewar, Roopwas, Bayan and Weir blocks.

The report on 'Ground water resources and development potential of Bharatpur district' was brought out by Central Ground Water Board in the year 1981 (Subhash Datta & M.K.M. Rao). Revised District report was brought out in the year 1997 (R.P. Mathur). Since its inception, the Central Ground Water Board has drilled 56 Exploratory wells, 3 Observation wells and 38 piezometers and 6 Slim holes in the district. Salient features of ground water exploration are listed in Table 2.

Since 1973, monitoring of ground water level is being carried out four times a year from National Hydrograph Network Stations. Presently, ground water regime monitoring is being carried out in the district from a network of 37 observation wells. Water levels are monitored four times in a year during the months of January, May, August and November. Samples for water quality analyses are collected during May.

Table 2: Salient Features of Ground Water Exploration

Type of well	No.	Depth drilled (m)	SWL (m)	T (m^2/day)	Discharge (lpm)	EC (micromhos/cm) at 25^{o}C
EW	56	30.09 – 207.28	– 1.79 – 83	6 - 787	3 - 2529	460 - 23300
OW	3	70 – 101	10.6 – 19		880	750 - 3400
PZ	38	32 – 184.6	0.95 – 84.7	27	10 – 3000	565 - 42260
SH	6	65.3 – 210.64	-2.00		95	5729 - 11690

2.0 Rainfall & Climate

The climate of the district being dry, it becomes extremely hot during summer and extremely cold during winter. The cold season is from December to February and is followed by summer from March to June. Period from mid of September to end of November constitute post monsoon season.

Average annual rainfall (1971-2011) of the district is 605.3 mm. The rainfall has decreased over the years. Annual rainfall data during the period 2001 – 2011 in given in Table 3. The average annual rainfall during the period 2001 – 2011 varied from 401 mm at Sikari to 741 mm at Sewar Bundh.

The district experiences either mild or normal drought once in two years. Severe type of drought was recorded in 1979. Most severe type of drought had occurred only in Nadbai subdivision in 1979 and Deeg subdivision in 1986. Moderate drought has also occurred in the district during 1987, 1989 and 1991.

Table 3: Annual Rainfall Data (2001-2011) (mm)

Station	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Ajan bundh	557	345	896	481.2	451	418.6	248	640	312	394	802	504.07
Baretha	469	359			589	409	398	813	538	499	590	518.22
Bayana	449	302	649	448	630	515	421	1059	635	733	947	617.09
Bharatpur	646	465	801	608	1041	373.5	539	786	643	754	743	672.68
Bharatpur		397.8	782.8	392.9	657.1	244.2	451.6	702.7	559	600.8	634.2	542.31
Bhusawar					599		289	662	344	515.6	694	517.27
Deeg	799	583	898	395	619	440	494	739	627	927	835	668.73
Halena				502	662		363	752	506	651	698	590.57
Hingota				367.6	600	239	424	714	361	675	716	512.08
Kaman	578	483	995	528	639	378	604	793	592	1022	559	651.91
Kumbher	578	355	555	516	491	266	414	746	825	770	986	591.09
Motijheel			650.5	336.5		0	167	0	0	0		164.86
Nadbai	661	375	685	651	830	411	482	840	574	761	774	640.36
Nagar	448	216	706	570	546.6	424	423	689	648	744	681	554.15
Pahari	528	391	791	525	590	266	513	645	390	669	531	530.82
Rupwas	440	422	680	640	670	670	524	735	459	905	674	620.64
Seola head				301	464	493	415	876	578	640	510	534.63
Sewar bundh	592	374	739	413	470	224	309	660	430	502	469	741.09
Sikari	394	223	687	184	483	280	428	593			337	401
Uchain				313	340		338	889	425	598	584	498.14
Weir	777	369	759.3	582	654	296	456	848	621	709	787	623.48

3.0 Geomorphology & Soil

Isolated hillocks in the northern part, vast plains occupied by alluvium and wind blown sand in central part and low lying flat topped hills in southern part of the district are the main physiographic units. The master slope of the district is easterly towards Yamuna River. Details of occurrence of various geomorphological units in the district are given in Table 4.

Table 4: Geomorphological units in Bharatpur district

Origin	Land Forms	Occurrence in the District
Fluvial Origin	Alluvial Plain	Formed due to fluvial activity, consisting of gravels, sand, silt and clay. Terrain mainly undulating.
	Valley Fills	Formed by fluvial activity at lower topographic level
	Ravines	Small, narrow, deep depression usually carved by running water.
	Flood Plain	Surface of relatively smooth land adjacent to a river channel. Subjected to periodic flooding.
Structural Origin	Plateau	Extensive flat landscape, bordered by escarpment on all sides. Formed over horizontally layered rock formation with steep slopes.
	Dissected plateau	Plateau, criss-crossed by fractures forming deep valleys.
Hills	Linear Ridges	Long narrow ridges having high run-off
	Structural Hills	Linear to arcuate hills associated with folding

Origin	Land Forms	Occurrence in the District
	Denudational Hills	Steep sided comprising of varying lithology with joints, fractures and lineaments.

3.1 Drainage

Bharatpur district falls in parts of Ruparel, Banganga and Gambhiri river basins. Tehsil wise distribution of basin area is given in Table 5.

Table 5: Tehsil wise distribution of basin area in Bharatpur district

S. No.	Name of Tehsil	Area in river basin (sq. km)		
		Banganga	Gambhiri	Ruparel
1	Pahari	3		483
2	Kaman	119		314
3	Nagar	162		308
4	Deeg	398		
5	Nadbai	439	0.4	
6	Kumher	508		
7	Bharatpur	468		
8	Weir	508	274	
9	Bayana	48	483	
10	Roopwas	61	466	

All the rivers in the district are ephemeral in nature. River Banganga, which passes through the south-central part of the district, disappears in the sandy tract near Ghana. Gambhiri River flows in the southern part, where as Ruparel flows in the northern part. Drainage density in the northern and central part varies between 0.2 and 0.3 km/km^2 whereas in the southern part, it varies from 0.3 to 0.5 km/km^2. There are four important lakes in the district viz. Moti Jheel, Keola Deo Jheel (Ghana Bird Sanctuary), Model Jheel and Jheel Ka Bara.

3.2 Soils

The soils of the Bharatpur district are greyish brown and yellowish brown with wide variation in texture from sandy loam to clayey loam. The soils at some places are affected by salinity/ alkalinity. The soils of Bharatpur, Bayana and Deeg subdivisions are fertile. In northeastern part of the district, the soils are compact and have low permeability, which causes water to stagnate on the surface during rainy season.

3.3 Irrigation:

The principal means of irrigation in the district are wells/tube wells and though some areas are irrigated by canals. Groundwater is the main source of irrigation and is utilized through dug wells, DCB's, and tube wells. Canals form the second most important source of irrigation in the district. Details of the area irrigated by different sources are given in Table 6.

Table 6: Area irrigated from different sources in Bharatpur district

(Area in Ha)

Source / Area	Canal	Tubewells	Other wells	Other sources	Total
Net irrigated	2287	320684	7334	129	330434
Gross irrigated	2362	323732	7404	129	333627

4.0 Groundwater Scenario

4.1 Geological Framework

Different formations belonging to Bhilwara super group, Delhi super group, Vindhyan group and Quaternary alluvium form the geological framework of the district. About 85% area of the district is occupied by alluvium and wind blown sand. The geological sequence in Bharatpur district is as follows:

SUPER GROUP	GROUP	FORMATION
Quaternary		Alluvium, wind blown sand.
VINDHYAN	Bhander	Sandstone, Shales & Limestone.
DELHI	Ajabgarh	Argillaceous meta sediments
(Proterozoic)	Alwar	Arenaceous meta sediments
BHILWARA & ARAVALLI (Archaean)		Granites, Granitic Gneisses

4.2 Hydrogeology

Groundwater usually occurs at shallow depths ranging from 25 – 30 m to less than 5 m and at places almost at ground level after rainy season. In most of the area, groundwater is phreatic, but semi-confined conditions occur in the central and eastern parts of the district. In Kumher area, confining conditions are prevailing till today.

Groundwater is mainly found in the Quaternary, unconsolidated beds. However, weathered zones, fractures, joints and fissure system in hard rocks belonging to Vindhyan super group also yield considerable amount of groundwater. Favorable groundwater potential zones in hard rock terrain occur in fractures and talus along subsurface contact of alluvium and quartzite ridges. Hydrogeological map of Bharatpur disytrict is presented in Fig. 2.

4.2.1 Unconsolidated Formation

Unconsolidated sediments cover the greater part of the district and consist of sand, gravel, silt, clay and Kankar within the flood plain province. The piedmont zone is characterized by talus & scree and fault debris material. These groundwater potential zones have favourable hydraulic properties and receive a major part of the surface run-off.

The alluvial flood plain in the Banganga River Basin is composed mostly of aeolian sand, gravel, silt and clay. The coarser component predominates in the western side of the district, while gradually decreasing in the east (direction of low energy flow regime), the proportion of finer clastics in the profile increases giving rise to semi-confined to confined conditions. In the west, only single phreatic aquifer is encountered. In the central part of the district, semi confined unit exists, whereas in the east, where alluvium attains its maximum thickness giving rise to third lowermost, mainly confined unit. These major ground water potential units separated by two major aquicludes are referred to as 1st, 2nd, and 3rd aquifers. The thickness of alluvium in Banganga basin varies from 120 to 180 m. The basement of the alluvium is formed by gneiss, sandstone and quartzite.

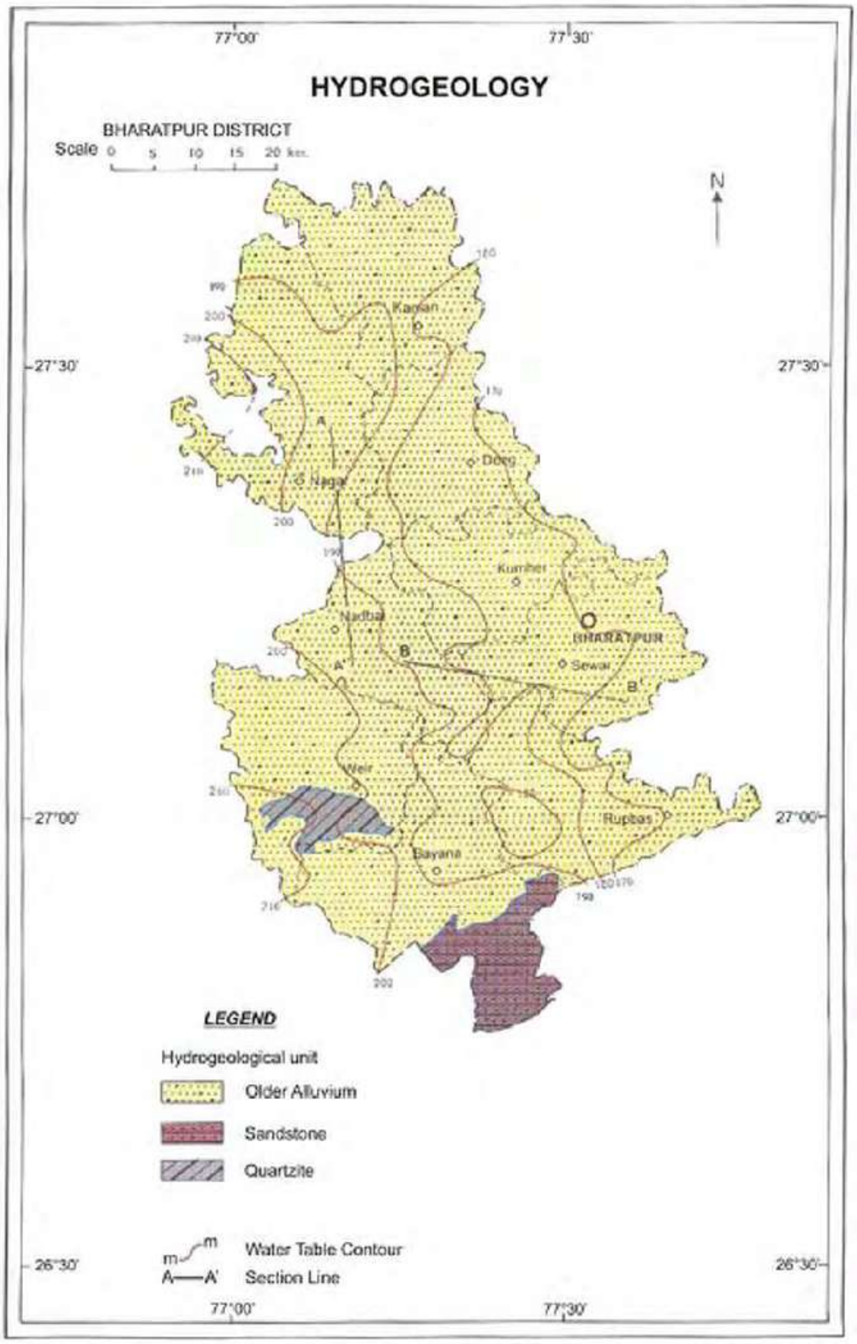

Figure 2: Hydrogeology

Lithological disposition along Nadbai, Ludhawai, Mallah and Chiksana indiactes that the maximum thickness of alluvium (160m) is encountered at Chiksana and minimum at Nadbai. The quantity of clay increases from Nadbai to Chiksana. Occurrence of clay and silt at various depths gives rise to multiple aquifer system. The basement rock encountered in all the boreholes is limestone.

In the northern part of the district (Ruparel Basin), basement is encountered at shallow depth as compared to central part. The thickness of alluvium is about 100m at Kaman and Sau. There is predominance of clay mixed with kankar and gravel thus forming poor aquifers. The yield of wells varies from 6 to 25m^3/hr.

In the southern part (Gambhiri River basin), generally single phreatic aquifer is encountered. The thickness of alluvium ranges from 60 to 100m. The maximum thickness of aquifer tapped is 18m in the depth range of 36 to 100m. Aquifer under confining pressure is found in limited area (Pachuna) where piezometric head ranges from 1 to 9 m bgl.

4.2.2 Hard Rock

Sedimentary and meta-sedimentary consolidated formations belonging to Vindhyans, Delhi and Bhilwara super groups form poor aquifers in the district. The groundwater occurs in the weathered zones and in secondary openings under unconfined conditions. There is no hydraulic inter connection among the aquifers. Hard rock aquifers occur mainly in parts of Roopwas, Bayana and Weir blocks. The consolidated water bearing formations are sandstones, quartzites, schists, gneisses and phyllites. The depth of wells constructed in these formations ranges from 85m to 160m. High yielding wells in Vindhyan sandstone have been constructed at Malpura Kachhi, Bakholi, and Ghantoli.

Summarized block wise groundwater conditions and development possibilities are listed in Table 7.

Table 7: Block wise ground water conditions and development possibilities

Block	Water Bearing Formation	Area (sq.km)	W.L. Range (mbgl)	Yield (000/LPD)	Quality	Stage of GW-Dev (%)
Bayana	Alluvium	527.86	3.0 – 24.0	80 - 110	Potable	97.64
	Sandstone	148.85	9.0 – 20.0	25 – 45	Potable	100.71
Deeg	Alluvium	338.91	5.0 – 13.5	80 - 110	Potable to slightly saline	100.68
	Alluvium	131.91	5.0 – 8.5	70 – 90	Saline	91.55
Kaman	Alluvium	492.93	1.5 - 18.5	80 - 110	Potable to saline	87.95
Kumher	Alluvium	119.08	4.5-14.5	80-100	Potable to slightly saline	100.10
	Alluvium	335.12	3.65-12.60	80-100	Saline	72.49
Nadbai	Alluvium	281.34	8.0-23.50	80-110	Potable to slightly saline	152.25
	Alluvium	165.36	7.8	70 - 80	Saline	105.09
Nagar	Alluvium	291.36	4.5-12.0	80 – 110	Potable to slightly saline	91.80
	Alluvium	319.68	4.0 – 12.5	80 – 110	Saline	37.82
Roopwas	Alluvium	501.10	3.0 – 17.5	70 – 110	Potable	85.32
Sewar	Alluvium	281.10	2.5 – 15.5	80 – 110	Saline to Potable	156.48

Block	Water Bearing Formation	Area (sq.km)	W.L. Range (mbgl)	Yield (000/LPD)	Quality	Stage of GW-Dev (%)
	Alluvium	228.27	5.0 – 10.5	100	Vertical variation is observed	60.32
Weir	Alluvium	353.44	6.0-37.0	80-110	Potable	153.82
	Quartzite	76.95	17.50	70	Potable	122.91
	Alluvium	158.66	5.15-25.90	80-100	Saline	75.79

4.3 Water Level Scenario

Central Ground Water Board periodically monitors groundwater levels through the National Hydrograph Network Stations (NHNS) in the district, four times a year during the months of January, May (Premonsoon), August and November (Postmonsoon).

4.3.1 Depth to Water Level – Premonsoon (May-2011)

During pre-monsoon (May, 2011), depth to water level in the district varied from 1.6 to 24.48 mbgl. Generally, over major part of the district, the depth to water level varies between 5 and 20 mbgl (Figure 3).

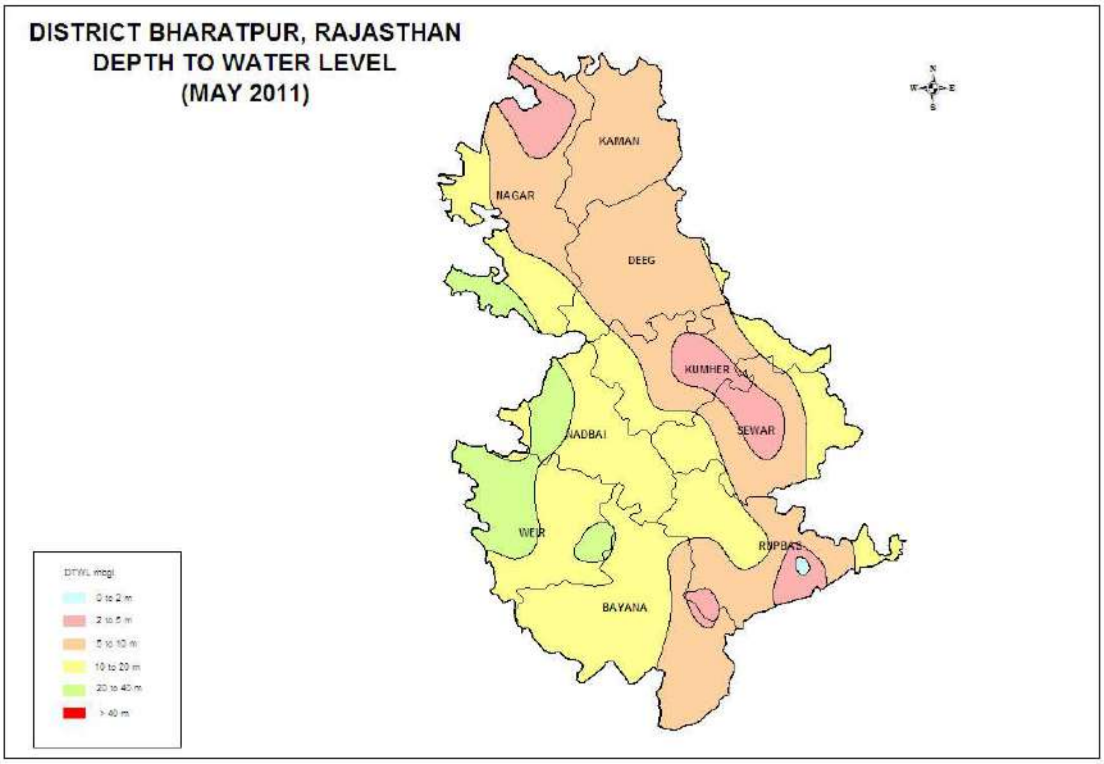

Figure 3: Depth to Water Level (May, 2011)

In flat areas and pediments ground water occurs in perched aquifers over impermeable rocks and is encountered at shallow depths. A small patch in the southeastern part of the district has been occasionally, at places, under water logging conditions and suffers from salinity problems. Depth to water level upto 10 mbgl has been recorded in Kaman, block, major parts of Nagar, Deeg, Kumher, Sewar and some parts of Roopwas and Bayana blocks. Depth to water level between 10 and 20 mbgl has been recorded in parts of all the blocks except Kaman. Deeper water levels (>20mbgl) have been observed in western part of the district falling in Nagar, Nadbai and Weir blocks.

4.3.2 Depth to Water Level – Postmonsoon (Nov-20011)

During postmonsoon (November, 2011), depth to water level varied from 0.34 to 28.08 mbgl. Depth to water level upto 10 mbgl has been observed in Kaman, Nagar, Deeg, Kumher, Sewar, Bayana and Roopwas blocks (Figure 4). Water levels in the range of 10-20 mbgl were obsderved in parts of Nagar, Kumher, Deeg, Sewar, Bayana, Weir and Nadbai blocks. Deeper water levels (>20 mbgl) were recorded in western part of the district covering parts of Nagar, Nadbai and Weir blocks.

The piezometric regime of the units underlying the phreatic aquifer is similar. An area of about 700km^2 east of Ludhawai is under confining condition. Flowing wells were observed at Kumher in the past but due to lowering of the head artesian condition no longer exist in the area.

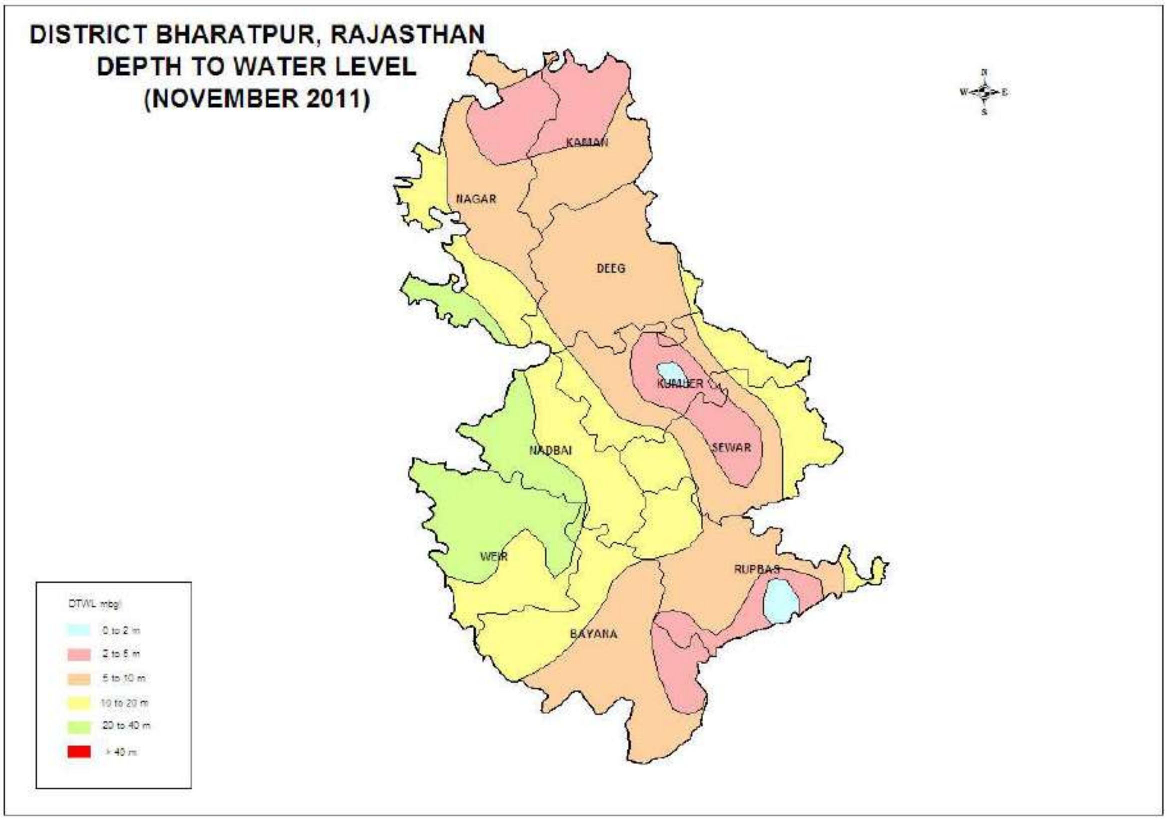

Figure 4: Depth to Water level Postmonsoon (Nov 2011)

4.4 Water Level Fluctuation

Analysis of water level data of Pre and Post Monsoon, 2011 indicates that there has been rise during post monsoon period in major part of the district (Figure 5). Major part of the district has recorded rise in water level up to 2m. Rise of more than 4 m has been observed in Bayana block. Decline of upto 2 m in water level has been observed in Nagar, Weir, Deeg, Kumher, Sewar, Nadbai and Roopwas blocks. Decline of 2 to 4 m was observed from small pockets in eastern parts of Deeg, Kumher and Sewar blocks and northern parts of Nagar block.

Analysis of long term water level data during premonsoon (May 2002 – May 2011) indicates that in major part of the district, water levels has registered declining trend of upto 25cm/year except small pockets in Kaman, Nagar, Kumher, Sewar, Deeg, Roopwas and Bayana blocks, where water levels have registered rising trend of upto 25 cm/year (Figure 6). These trends are a result of over-exploitation of the aquifer coupled with apparent downward departures of annual rainfall from long term average.

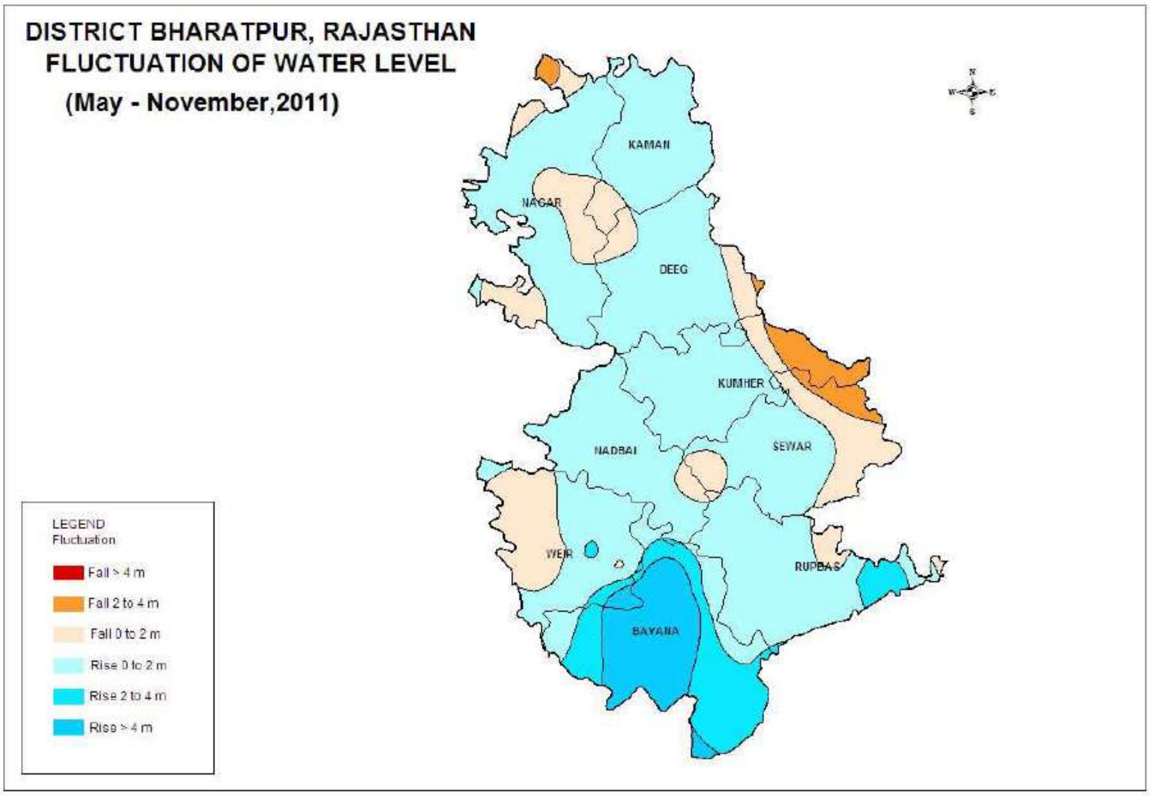

Figure 5: Seasonal Water Level Fluctuation (May – Nov 2011)

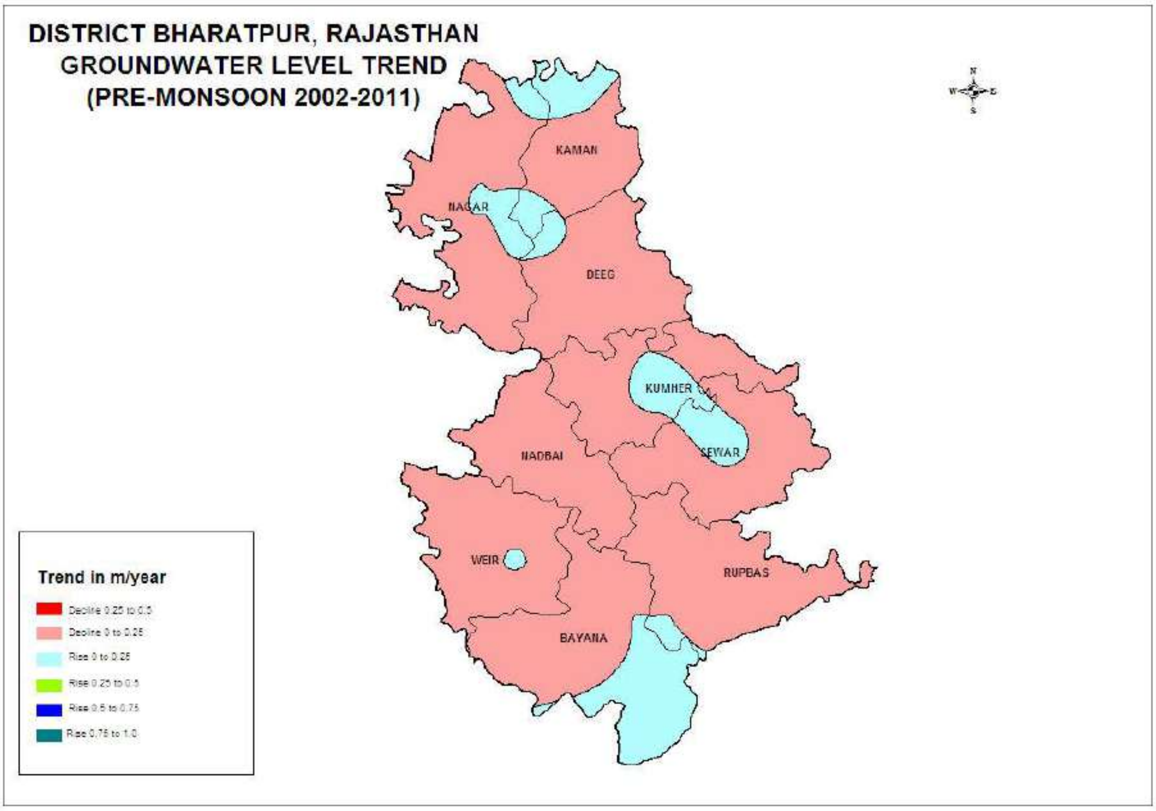

Figure 6: Decadal ground water trend (May, 2002 – May, 2011)

5.0 Ground Water Resources

Central Ground Water Board and State Ground Water Department (GWD) have jointly estimated the groundwater resources of Bharatpur district as on 2009 based on GEC-1997 methodology. The same are presented in Table 8. The entire area of the district falls under non command area and has been covered under assessment.

Total annually replenishable groundwater resources of the district have been estimated to be 495.68-mcm and net annual groundwater availability as 453.51 mcm. Total annual groundwater withdrawal for all uses as on 2009 was estimated as 508.56 mcm with stage of groundwater development at 112.14 mcm.

Table 8: Ground water resources of Bharatpur district (As on 2009)

Block	Annually replenishable groundwater resource (mcm)	Net annual groundwater availability (mcm)	Existing gross groundwater draft for irrigation (mcm)	Existing gross groundwater draft for domestic and industrial use (mcm)	Existing gross ground water draft for all uses (mcm)	Stage of ground water development (%)	Category
Bayana	89.7280	81.2273	74.4012	6.3579	80.7591	99.42	C
Deeg	46.6528	41.9875	37.4328	4.1756	41.6084	99.10	C
Kama	67.8364	61.0528	44.4060	5.1323	49.5383	81.14	SC
Kumher	18.0343	16.2309	12.6936	4.7527	17.4463	107.49	OE
Nadbai	42.7397	38.4657	59.2956	4.7567	64.0523	166.52	OE
Nagar	50.8325	48.2909	37.9824	6.0152	43.9976	91.11	C
Roopwas	86.6287	77.9658	70.0200	5.3615	75.3815	96.69	C
Sewar	37.7473	35.8599	40.8060	15.4738	56.2798	156.94	OE
Weir	55.4778	52.4292	69.4704	10.0306	79.5010	151.63	OE
Total	495.6775	453.5100	446.5080	62.0562	508.5642	112.14	OE

6.0 Ground Water Quality

Variation in groundwater quality is observed both in shallow and deeper aquifers. Electrical conductivity in the district varies from 485 µS/cm at 25°C at Bandh Bareta in Bayana block to 13270 µS/cm at 25°C at Bharatpur. In southern part of the district (Bayana and Roopwas blocks), groundwater is generally fresh with EC less than 2000 µS/cm at 25°C (Figure 7). In southeastern part of Kaman block, similar situation prevails. In parts of Roopwas, Kaman, Bayana, Kumher, Nadbai and Weir blocks, EC of shallow groundwater varies from 2000 to 3000 µS/cm at 25°C.

Electrical Conductivity in the range of 3000 – 5000 µS/cm at 25°C has been observed in parts of almost all the blocks. Electrical Conductivity between 5000 and 10000 µS/cm at 25°C has been recorded from parts of Kaman, Deeg, Nagar, Kumher and Sewar blocks. Electrical Conductivity value of more than 10000 µS/cm at 25 °C has been reported from central part of Sewar block.

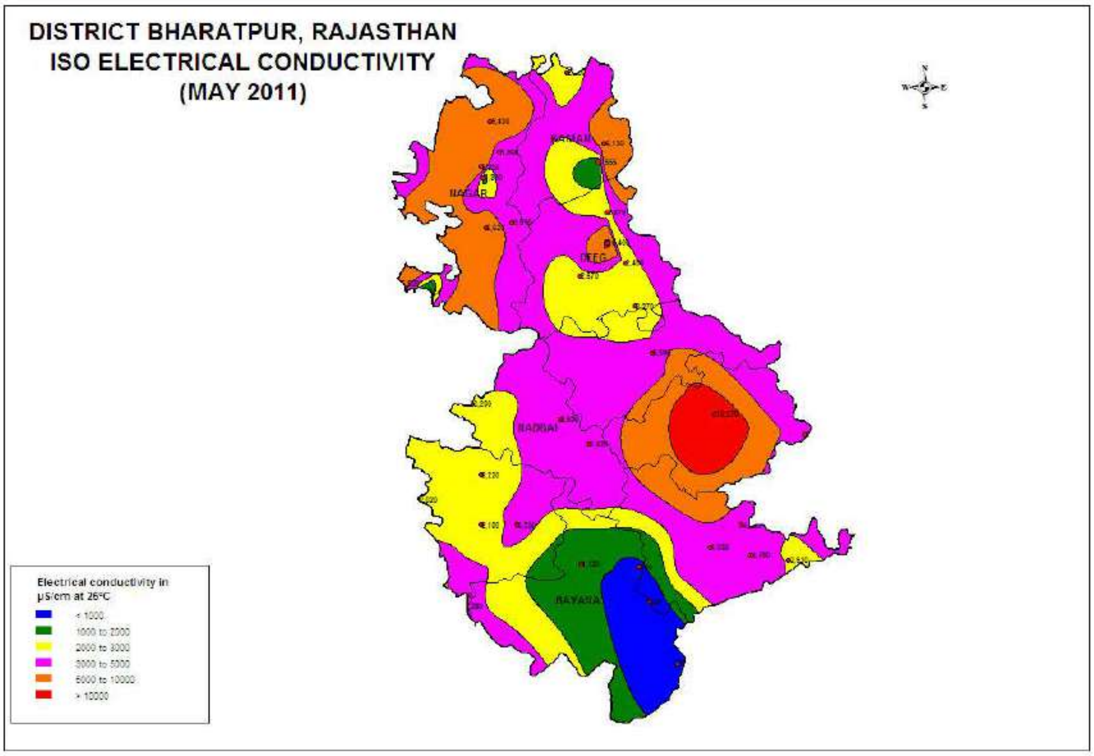

Figure 7: Iso Electrical Conductivity (May, 2011)

The principal reasons for the severe groundwater quality problem are:

- The Banganga and Ruparel terminate in an internal drainage basin. It is estimated that flood waters of these rivers carry 100,000 tons of solute load annually (Water Resources Planning for Banganga River Basin-1998) which are concentrated by evaporation and seep into shallow ground water.

- Further, concentration is brought about by evaporation from the water table i.e. by capillary rise due to shallow water table and clayey lithology of formations.

- All solutes transported to this area by means of surface/subsurface flow remain in-situ as there seems to be no flushing out of salts from the closed basin.

Fluoride concentration in groundwater in the district has been found to vary from 0.1 mg/litre at Bhagori in Bayana block and Jurahara in Kaman block to 9.42 mg/litre at Jhantli in Nagar block. Flouride content is generally within the permissible limit of 1.5 mg/litre (Figure 8). However, major parts of Nagar, Kaman, Nadbai, northwestern and northeastern parts of Deeg, western parts of Weir, Bayana, Kumher and Sewar and northwestern part of Roopwas have fluoride content above the permissible limit.

Nitrate concentration in groundwater varies from 1.5 mg/litre at Bharatpur to 327 mg/litre at Nadbai. Higher concentration of Nitrate exceeding maximum permissible limit of 45 mg/litre has been reported from parts of Bayana, Roopwas, Kumher, Nadbai and Nagar blocks (Figure 9).

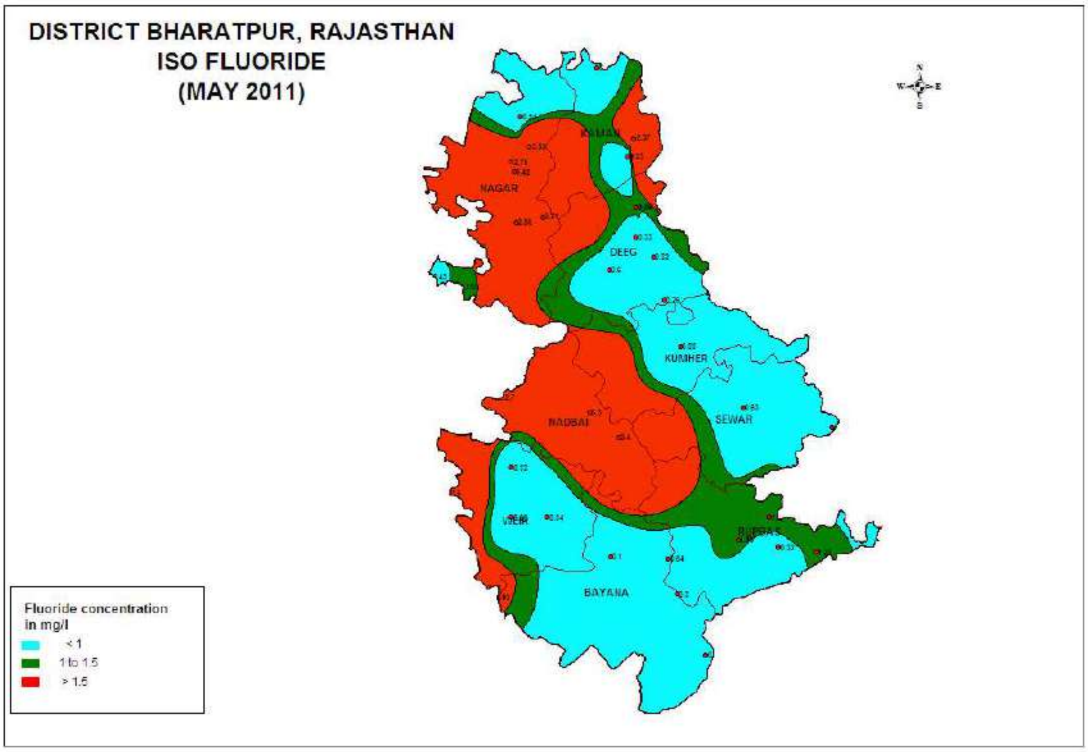

Figure 8: Iso Fluoride (May, 2011)

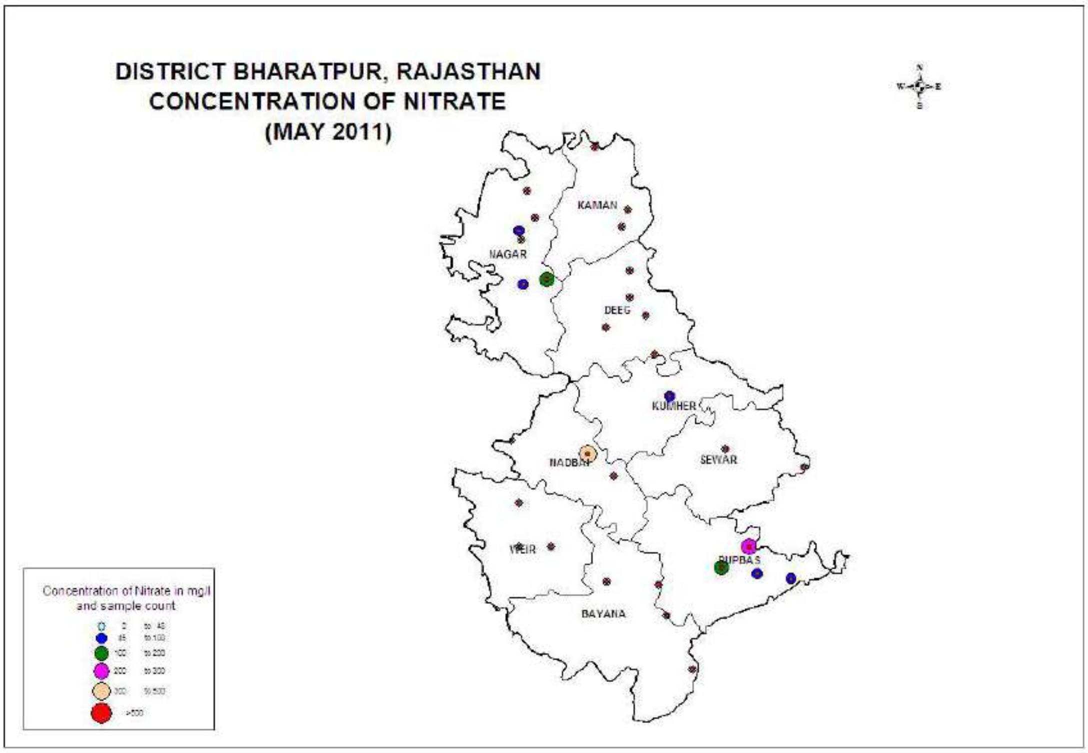

Figure 9: Distribution of Nitrate (May, 2011)

Iron content in groundwater has been found to vary from negligible to 5.41 mg/litre. Iron concentration above permissible limit of 1 mg/litre has been reported from major part of the district (Figure 10). Almost all the blocks are affected by problem of iron contamination in ground water.

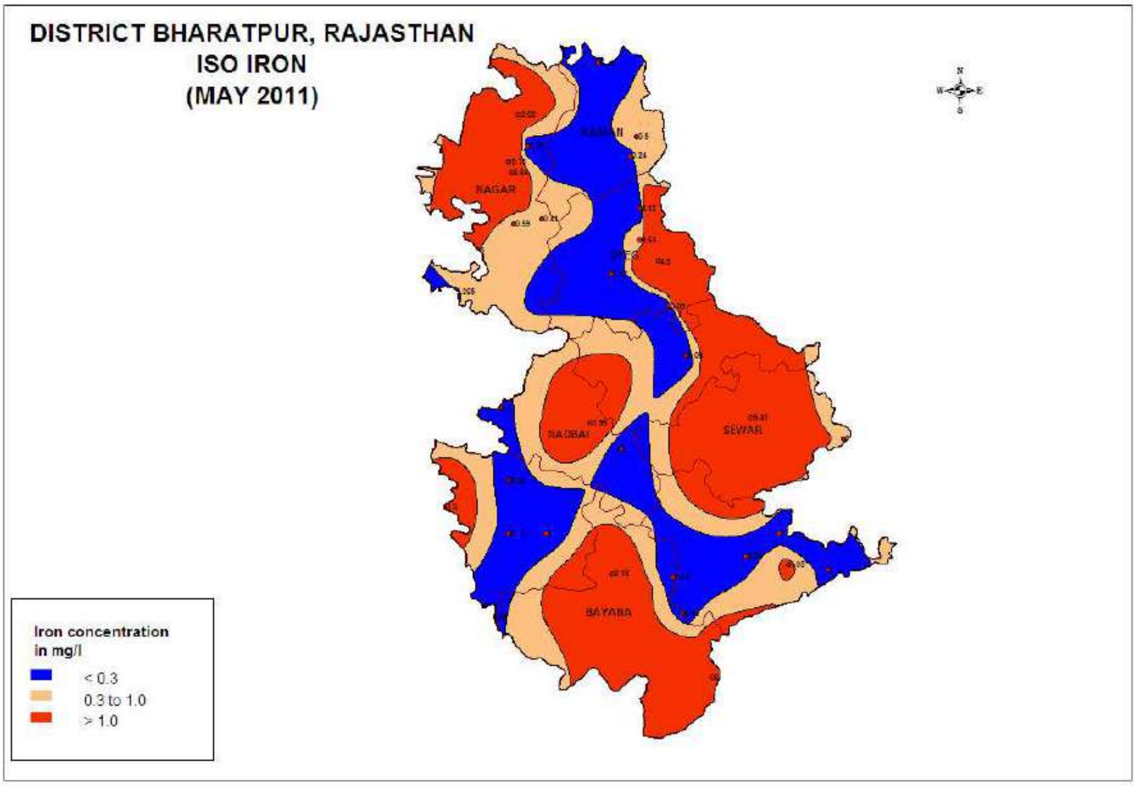

Figure 10: Iso Iron (May 2011)

At ***deeper levels*** groundwater is fresh in northwest – southeast trending belt in parts of Weir and Bayana blocks. Marginal quality of water occurs in most part of Roopwas and Sewar blocks. In western part of Nadbai and northern part of Kumher block, deeper groundwater is saline. It is observed that areas with fresh water at all levels extend from Weir, Hingota to Bayana and Samogar. Depth wise variation in chemical quality of water is also observed in some areas. In parts of Sewar and Roopwas blocks, fresh water is overlain by saline water. In very small area, marginal to fresh water overlying the saline water occurs in Sewar and Kumher blocks. List of places where extremely high salinity has been recorded in exploratory wells is given below in table 9.

Table 9: Locations of Exploratory wells having high salinity

Name	**EC**	**Cl (ppm)**
Gangrauli	15980	4325
Halena	23300	7516
Kamalpura	19115	6275
Kumher	13248	4325
Sahari	22240	6887
Bahai	22180	6133
Nadbai	8420	1828

7.0 Status of Groundwater Development

Groundwater is the principal source of irrigation in the district. Ground water development in the district is being done through cavity wells/ tube wells. In the district, at present 46082 wells including cavity wells/ tube wells are in operation for irrigation purpose. In addition for drinking purpose use, 4011 wells and 11371 hand pumps are in operation. Out of 9 blocks, 4 blocks fall under over-exploited category, 4 under critical category and the remaining 1 block falls under semi-critical category.

8.0 Groundwater related issues and Problem

Potential aquifer zones in the district have witnessed heavy ground water withdrawals leading to lowering of water levels. Four blocks in the district are over exploited and four blocks fall under critical category. Such areas require attention of water resources managers for implementation of regulatory mechanisms to check and regulate ground water withdrawals and adoption of suitable artificial recharge measures. Many areas in the district are affected by problem of salinity, Fluoride and Iron contamination.

9.0 Groundwater Management Strategy

Due to pressure of population and improvement in the standard of living, the demand of fresh water for both agriculture and domestic uses has substantially increased. As surface flow is available only for a limited period, groundwater withdrawal has sharply increased. The top layer of fresh groundwater is also reducing every year. Artificial recharge serves as a means for restoring the depleted groundwater storage, slow down the quality deterioration and put back into operation many groundwater abstraction structures.

9.1 Groundwater Development

As per groundwater resource estimation 2009, stage of ground water development is 112.14%. Four blocks are already over-exploited. Therefore, there is no scope for further ground water development in these blocks. Four blocks in the district are critical, where caution needs to be exercised in further development of ground water resources. The remaining one block is semi-critical, where further ground water development can be undertaken with simultaneous adoption of artificial recharge measures.

Rainfall is the main source of groundwater recharge in the district. Due to less rainfall and increased groundwater withdrawal, the groundwater level is depleting at a rate of 0.12m/yr, as a result of which salinity in groundwater is also increasing. High salinity is observed in the downstream areas of Banganga and Ruparel rivers.

9.2 Rejuvenation & Restoration of Reservoir and Canals

In the back drop of the above situation, it is the need of the hour to restore and increase storage capacity of our traditional water conservation structures viz. village ponds, anicuts, earthen dams, tanks and canals to meet the future domestic, agriculture and industrial demands.

Bharatpur encompasses world famous water conservation and surface water inundation irrigation system built on three rivers flowing through the district. The inundation irrigation system includes diversion of surplus river flow from the river through canals, inundation of large area and storage of water in small and medium shallow reservoirs. Surface water conservation is done through 197 no. of earthen dams with total storage capacity of about 226.7047 mcm. There are total 90 canals with 650 km length. This unique system withstood test of time as it provided agricultural base to large population. It also helped in replenishing the phreatic aquifer with fresh water and suppressing groundwater salinity.

The current inundation irrigation is regarded more as groundwater recharge method than an irrigation method. Off late farmers are providing irrigation through open wells which are constructed near to canals, tanks and ponds. These wells are also used as the source for drinking water. Such wells use the recharged groundwater for irrigation, which is bound to raise irrigation efficiencies. The existing system is not operating properly because of inadequate capacity of diversion channels, silting of canals, riverbeds and detention reservoirs. There is need to restore the existing irrigation system through desilting measures.

9.3 Water Conservation and Artificial Recharge

Groundwater level is depleting in the alluvial zones in the many blocks in the district indicating that artificial recharge to groundwater is feasible in principal. For full utilization of surface water, specially excavated skimming wells/ cavity bore wells may be constructed at the base of canal, catchment of ponds or in low lying areas. These structures may be used to recharge groundwater during monsoon and as groundwater abstraction structures during lean period.

In Gambhiri river basin, surplus surface water is available. Hence small scale, inexpensive flow retarding structures can be constructed at many places on the main river or on its tributaries. Suitable hydrogeological conditions for artificial recharge have been identified in Bayana, Roopwas, Weir, Deeg and Kaman tehsils. Technical and economic feasibility, site conditions etc. have been studied by Irrigation Department, Govt. of Rajasthan. Construction of anicuts in different hydrogeological and agro-climatic conditions has proved to be effective in recharging groundwater, controlling decline in groundwater level and mitigation of groundwater quality problems.

There is need to create awareness among the users about the need and ways of water conservation and artificial recharge. Various water conservation measures like use of drip/sprinkler irrigation techniques, adopting of suitable cropping pattern and sowing of less water requiring crops etc. need to be promoted

10.0 Conclusion

Bharatpur district faces problem of fresh water availability in many areas. Water levels have declined over a major part of the district. Out of 9 blocks in the district, four are Over-exploited and four blocks are critical. Necessary measures to check withdrawal of groundwater are required to be adopted. Further water conservation and artificial recharge measures need to be prompted and practiced on large scale. Saline water can also be used for growing salt tolerant crops.