Article

Assessment of groundwater quality and pollution potential of Jawa Block Rewa District, Madhya Pradesh, India

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Abstract
The paper deals an assessment of groundwater quality and pollution potcntial of Jawa block, Rewa district, Madhya Pradesh India. Geologically, the area is occupied by shale and sandstone of Rewa Group, Vindhyan Supergroup. Interpretation of analytical data shows Ca-Mg-HCO_3 and Ca-Mg-SO_4-Cl facies. The chemical parameters- hardness, sulphate and total dissolved solid exceed the desirable limit in few locations which should be use for drinking after some chemical treatments. The higher concentration of nitrate may be due to excessive use of fertilizers, pesticides and insecticides. The fluoride is generally within permissible limit with few exceptions. The computed DRASTIC Index suggests intermediate to high pollution susceptibility. The interpretation on the basis of available data shown that the groundwater of the area was more or less fit for drinking.

Keywords groundwater quality; DRASTIC; Jawa; Madhya Pradesh India

1 Introduction

Groundwater quality is one of the most important aspects in water resource studies (Ackah et al., 2011; Sayyed and Wagh, 2011). It is largely controlled by discharge recharge pattern, nature of the host and associated rocks as well as contaminated activities (Raghunath, 1907; Sayyed and Sayadi, 2011; Zhang et al., 2011). The analyzed chemical parameters of groundwater have important role in classifying and assessing water quality. The chemical quality of groundwater of the Vindhyan region has been studied by various works (Tiwari et al., 2009; Tiwari et al., 2010; Mishra, 2010). However in the present study an attempt has been made to evaluate the drinking water quality and pollution of Jawa block, Rewa district Madhya Pradesh (Fig. 1).

The study area lies between 24^0 45'N to 25^0 00' N Latitude and 81^0 20' to 81^0 35' E Longitude, covering about 700 Sq. Kms area. The climate is semi arid to humid type. The average annual rainfall is about 1000 mm which has decreasing trend in last five years. Agriculture is main occupation of the area and it is highly fertile due to alluvium deposit of Tons river.

2 Geology and Hydrogeology

The area is underlain by Rewa sandstone and shale of Neoproterozoic Vindhyan Supergroup with thick recent alluvium formations. The sandstone is medium to coarse grained red and brown in colour and chemically quartz arenite type. The shale in thinly bedded and well laminated with chocolate reddish brown in color. The important geomorphic feature present in the area pediplain, pesiment, valley fills and denudational hills.

Hydrogeologically, the area is hard rock terrain, lying in Pre-Cambrian sedimentary province (Karanth, 1987). Due to high silica cementation in sandstone, the primary porosity is low. Secondary porosity in the form of joints, fractures, bedding planes and weathered pediments are favorable for the groundwater exploitation (Tiwari et al., 2010). The groundwater occurs in both semi-confined and confined conditions.

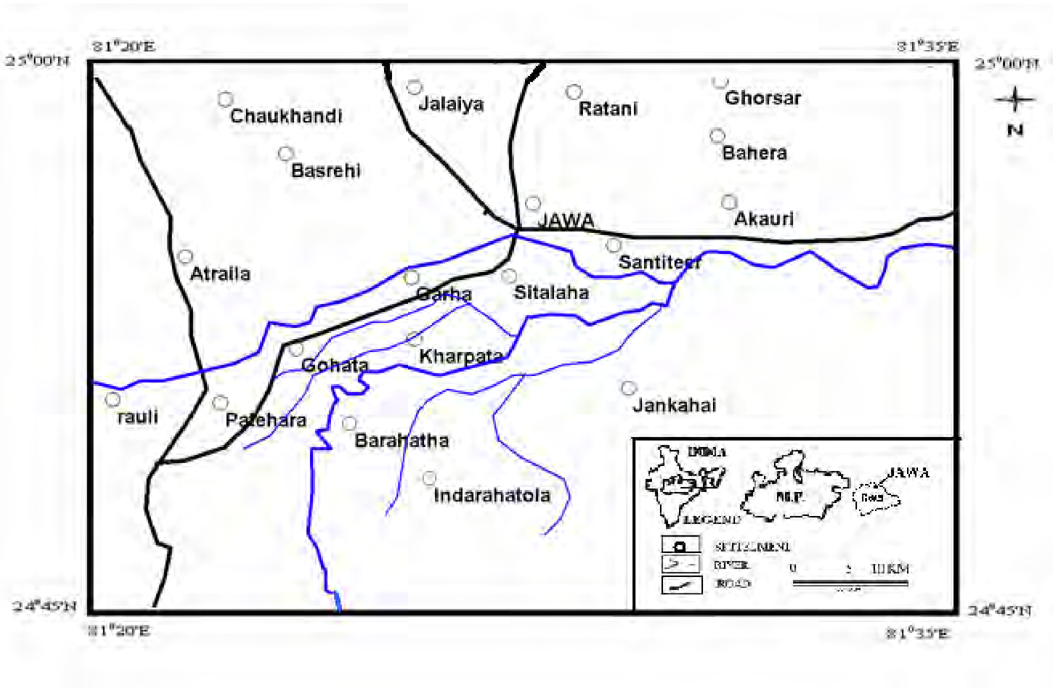

Fig. 1 Location map of the study area

3 Methodology

Thirty ground samples were collected in one liter clean polythene bottles during November 2010 to cover the entire area and analyzed for various chemical parameters following standard method (APHA, 1998). The Electrical conductivity (EC) total dissolved solids (TDS) and total hardness (TH) were measured in the field. Calcium, magnesium, sodium, potassium, chloride, bicarbonate, sulphate, fluoride and nitrate were determined in the laboratory. For the Computation of pollution potential DRASTIC modelling (Aller et al., 1987) has been adopted.

$$D1 = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + T_R T_W + I_R I_W + C_R C_W$$

where R= rating, W= weightage.

4 Results and Discussion

The major anions and cations present in the groundwater samples are given in Table 1. The p^H values vary from 7.0 to 8.0(average, 7.5), which indicates alkaline nature. The electrical conductivity of groundwater sample of the study area varies from 358 mg/l (Belgawa) to 1280mg/l (Andwa) in sandstone and 754mg/l (Jonha) to 3285 mg/l (Basrehi) in shale. Higher concentration of electrical conductance in shale may be due to the enough time for reaction between groundwater sample and impervious shale. The sandstone litho units have comparatively lesser amount of EC due to its hydrological characters. The total dissolved solids (TDS) varies between 229 mg/l (Belgawa) to 825 mg/l (Jhalwa) in sandstone whereas in shale from 305 mg/l (Chandi) to 1691mg/l (Bhungeon). The water with TDS upto 1000, mg/l is considered to be suitable for drinking (Jasrotia and Singh, 2007; Tiwari and Singh, 2010).The higher amount of TDS may cause gasterointestinal irritation in human body. Calcium and magnesium along with their carbonates, sulphates and chlorides, make the water hard both temporarily and permanent. As per Sawyer and McCarty (1967) scheme, the hardness is classified as 0-75 (soft), 75-150 mg/l moderately (soft), 150-300 mg/l (hard) and >300 mg/l very hard. The total hardness varies between 217 mg/l (Santiteer; soft) to 417 mg/l (Jhalwa; very hard) in sandstone while in the shale the total hardness varies between 268 mg/l (Pateri; hard) to 1691 mg/l (Bhungeon; very hard). The possibility of groundwater hardness in the area may be due to calcareous cement in sandstone. The content of calcium in sandstone aquifers varies from 7.5 mg/l (Santiteer) to 120.20 mg/l (Garhwa) while in shale, and the range of concentration varies from 30.8 mg/l (Dondow) to 346.2 mg/l (Bhungeon). The magnesium concentration in water sample from sandstone ranges 4.1 mg/l (Santiteer) to 61.8 mg/l (Jhalwa) while in shales, and the concentration varies 25.60mg/l (Sitalaha) to 201.40mg/l (Bhungeon). The concentration of sodium ranges from 4.5 mg/l (Belgawa) to 24.40 mg/l (Andwa) in sandstone aquifers whereas it varies from 14.00mg/l (Koniya) to 115.00 mg/l (Kuthila) in shale lithounit. Similarly, concentration of potassium varies between) 0.50 mg/l (Belgawa) to 15.90 mg/l (Mahilo) in sandstone and 1.00 mg/l (Pateri) to 8.60 mg/l (Basrehi) in shale formations. It seems that the clay minerals present in sandstone and shales contributed these two constituents to the groundwater of the area. In the present study, the groundwater sample from sandstone have sulphate concentration ranging from 16.70 mg/l (Garhwa) to 194.00mg/l (Jhalwa) while in the case of water samples from shaly aquifers, the concentration range of sulphate varies from 35.80mg/l (Ganj) to 568.00mg/l (Basrehi). The higher concentration of sulphate is due to the gypsum and baryte nodules associated with shale. The concentration of chloride in sandstone aquifer varying from 28.60 mg/l (Belgawa) to 115.5 mg/l (Chandi) while the water samples from aquifer in shale have chloride concentration ranging between 42.90mg/l (Nagwa) to 572.00 mg/l (Bhitari). The water samples from sandstone aquifers have bicarbonate ions ranging between 20.00 mg/l (Belgawa) to 385.00 mg/l (Andwa) while the shale formation have the range of bicarbonate ions between 220.00 mg/l (Pateri) to 900.00 mg/l (Basrehi).

The sixty percent of samples show concentration of nitrate more them the permissible limit of 45mg/l. Various workers have related nitrate in groundwater from different sources viz. leakage from septic tank, leaching from animal waste and nitrogen fertilizers (Pawar and Shaikh, 1995; Pacheco et al., 2001, Bhartiya and Agrawal, 2004; Babu et al., 2007). The nitrate poses some unique problems to groundwater because it moves quickly through the soils with percolating water and it often indicates potential biological contamination.

The groundwater resources contaminated with high levels of nitrate (> 45 mg/1 as NO_3 or 10 mg/1 as NO_3-N) are an environmental hazard. Urea is common type of fertilizer used in the agriculture due to its higher N content, highly solubility and non-polarity (Table 2). Urea is first converted to ammonium carbonate and then to nitrate. In comparison with this, the solubility of phosphate fertilizers is low and it adsorbed on the soil. In the present study chemical fertilizers and pesticides seem to be possible source of nitrate because farmers are excessively using them as confirmed from the Table 3. In the study area the wells located in the area under double crop have comparatively higher nitrates than those located near the single coop. Since the water is occurring at higher depth, the denitrification process would not be very effective due to longer residence time of infiltrating water in vadose zone and degradation of organic carbon during the longer course of percolation.

The higher concentration of fluoride may be due to the presence of F^- bearing minerals (biotitic and clay minerals) in aquifers as well as leaching action from other sources. As the evident from Table 1, higher concentration of fluoride is strongly related with pH indicating that higher alkalinity of the water promotes the leaching of F^- and thus affects the concentration of F^- in the groundwater (Saxena and Ahmed, 2001; Madhnure et al., 2007; Chatterjee et al., 2008; Duraiswamy and Patankar, 2011). To ascertain the suitability of groundwater for drinking purpose the geochemical parameters of the study area were compared with the guidelines as recommended by WHO (1984) and ISI (1991) which indicate that groundwater of the study area is more or less suitable for drinking purpose (Table 3).

Table 1 Geochemical Analyses of Groundwater Samples of the study Area (Except pH and EC, all values are in mg/l)

Litho logy	**LOCATION**	**P^H**	**EC**	**TDS**	**TH**	**Na**	**K**	**Ca**	**Mg**	**F**	**Cl**	**SO_4**	**NO_3**	**HCO_3**
SSt./1	JAWA	7.3	822	527	320	**14.2**	**2.3**	**80.8**	**28.9**	1.00	**57.25**	**108.6**	**95.00**	140.00
SSt./2	BHAKHAR WAR	7.0	887	569	279	**22.8**	**3.50**	**62.3**	**30.00**	**.50**	**64.8**	**125.4**	**100.00**	160.00
SSt./3	JHALWA	7.6	1286	825	417	**15.5**	**3.5**	**65.5**	**61.8**	**2.00**	**57.2**	**194.0**	**105.00**	**320.00**
SSt./4	BELGAWA	7.8	358	229	98	**4.5**	**0.5**	**20.00**	**11.8**	**1.5**	**28.6**	**52.5**	**90.00**	**20.00**
SSt./5	SANTITEER	7.6	423	271	36	5.2	0.5	7.5	4.1	1.5	42.9	52.5	97.00	60.00
SSt./6	AKAURI	7.3	639	410	166	6.8	1.3	38.50	16.9	1.4	39.65	116.5	48.00	142.00
SSt./7	CHANDI	7.4	703	451	218	15.2	1.3	45.3	25.6	-	115.5	26.8	86.00	135.00
SSt./8	MAHILO	7.0	683	438	126	19.10	15.90	30.60	12.00	1.6	45.6	85.00	43.00	185.00
SSt./9	INTOURI	7.5	549	352	265	17.10	3.01	45.30	37.10	1.00	28.30	28.10	8.00	184.00
SSt./10	BARAULI	7.2	570	366	353	35.10	4.15	85.20	34.20	1.54	39.20	20.20	5.00	141.10
SSt./11	GARHWA	7.2	770	493	382	16.30	2.60	108.20	27.25	0.35	99.25	16.70	48.00	175.00
SSt./12	ANDWA	7.8	1280	821	373	25.40	3.10	107.20	25.60	1.10	65.20	185.00	23.00	385.00
SSt./13	RAMBAG	7.7	528	338	358	18.10	4.00	65.20	47.60	1.00	30.20	19.20	18.00	135.00
Sh./14	SHIVPUR	7.3	1436	921	642	28.6	1.15	210.3	28.3	.50	105.6	123.6	37.00	386.00
Sh./15	PATERI	7.4	945	606	268	70.8	1.00	56.2	31.0	1.0	42.9	156.00	27.00	220.00
Sh./16	SITALAHA	8.0	1383	887	351	18.5	1.00	98.50	25.6	2.8	122.6	120.5	98.00	402.00
Sh./17	NAGWA	7.3	1291	827	379	35.5	1.00	14.00	84.0	1.0	42.9	284	5.00	360.00
Sh./18	BHUNGEON	7.5	1985	1272	1691	40.00	5.1	346.2	201.4	1.5	57.2	156	65.00	400.0

Litho logy	**LOCATION**	**P^H**	**EC**	**TDS**	**TH**	**Na**	**K**	**Ca**	**Mg**	**F**	**Cl**	**SO_4**	**NO_3**	**HCO_3**
														0
Sh./19	DONDOW	7.5	3186	2043	804	75.2	3.2	30.8	177.4	2.5	224.5	624	5.00	900.0 0
Sh./20	DAGDAIYA	7.7	2586	1658	547	75.6	2.2	112.5	64.7	1.5	572.0 0	117	72.00	640.0 0
Sh./21	CHANDI	7.3	1630	1045	305	15.0	3.8	62.5	36.2	0.5	572.0 0	105	70.00	180.0 0
Sh./22	KONIYA	7.3	1539	987	340	14.00	4.00	70.00	40.2	0.5	429.0 0	85.00	64.00	280.0 0
Sh./23	BHIATARI	7.4	2069	1327	498	14.20	4.00	102.5	58.9	1.0	572.0 0	156.0 0	58.00	360.0 0
Sh./24	KUTHILA	7.3	2695	1728	933	115.0	6.5	192.5	110.3	1.5	85.8	468.0 0	48.00	700.0 0
Sh./25	BASREHI	7.5	3285	2106	1325	40.00	8.6	267.5	160.1 0	1.0	114.4	568.0 0	46.00	900.0 0
Sh./26	GANJ	7.6	1236	793	385	21.30	3.25	108.3 5	27.8	1.7	96.00	35.8	50.00	450.0 0
Sh./27	JONHA	7.5	1175	754	495	14.5	4.00	102.5	58.3	1.0	57.2	250.0 0	46.00	220.0 0
	AVERAGE	**7.5**	**1331. 1**	**853.5**	**457.6**	**29.4**	**3.5**	**93.9**	**54.3**	**1.2**	**141.0**	**158.5**	**54.0**	**317.8**

Table 2 Use of fertilizers for different crop in the area.

S.No.	Crop	fertilizer kg/acre and pesticides liter/acre used			
		Mix (N:K:P)	Super Phosphate	Urea	Pesticides
1.	Wheat	50		50	2 Liter 2 times
2.	Gram		50		
3.	Pea	50			1 Liter
4.	Mustard			25	
5.	Jawar	45		25	1 Liter
6.	Tur	45		50	2 Liter 2times
7.	Soya bean		75		2-4Liter 2-4 times

Informations collected from Farmers

Table 3 Comparison of the quality parameters of groundwater of the study area with WHO and ISI for drinking purpose

S. No.	Water Quality Parameters	WHO (1984)		ISI (1991)		Concentration in Study Area	Undesirable Effect Produced Beyond Maximum Allowable Limit
		Max. Desirable	Max. Permissible	Max. Desirable	Max. Permissible		
1.	pH	7.0 to 8.5	6.5 to 9.2	6.5 to 8.5	No relaxation	7.0 to 7.8 (Sandstone) 7.3 to 8.0 (Shale)	Taste, effects mucus memberane and water supply system.
2.	TH mg/l	100	500	300	600	36 to 417 (Sandstone) 268 to 1691 (Shale)	Encrustation in water supply and adverse effect on domestic use.
3.	TDS mg/l	500	1500	500	1000	229 to 821 (Sandstone) 606 to 2106 (Shale)	Gastrointestinal irritation.
4.	Ca mg/l	75	200	75	200	7.5 to 108.20 (Sandstone) 14 to 267.50 (Shale)	Encrustation in water supply, scale formation.
5.	Mg mg/l	30	150	30	100	4.1 to 61.8 (Sandstone) 27.8 to 177.40 (Shale)	Encrustation in water supply and adverse effect on domestic use.
6.	Na mg/l	-	200	-	200	4.5 to 35.10 (Sandstone) 14.20 to 115.00 (Shale)	--
7.	Cl mg/l	200	600	250	1000	28.60 to 115.50 (Sandstone) 42.9 to 572.00 (Shale)	Salty Taste
8.	SO_4 mg/l	200	400	150	400	16.70 to 194.00 (Sandstone) 35.8 to 568.00(Shale)	Laxative effect.
9.	F mg/l	0.6 to0.9	0.8 to1.7	1.00	1.5	0.35 to 2.00 (Sandstone) 0.50 to 2.80 (Shale)	Excessive fluoride causes skeletal and dental fluorosis in both children and adult
10.	NO_3 mg/l	45mg/l	100	45	100	5 to 105 (Sandstone) 5 to 98 (Shale)	Blue baby disease, carcinogenic diseases

The analyzed data has been plotted on Chadha's (1999) diagram. It has all the advantage on the diamond shaped field of the Piper's trilinear (1953) and can be also used to study various hydro-chemical processes such as base cation exchange, actual ion concentration, mixing of natural waters and sulphate reduction and other related hydro-chemical problems. In the study area; out of 30 groundwater samples,11 sandstone samples and 8 shale samples fall in the subfield -5 of Ca-Mg-HCO_3 type whereas 2 sandstone samples and 9 shale samples fall in the subfield 6 indicating Ca-Mg-Cl-SO_4 type (Fig. 2).

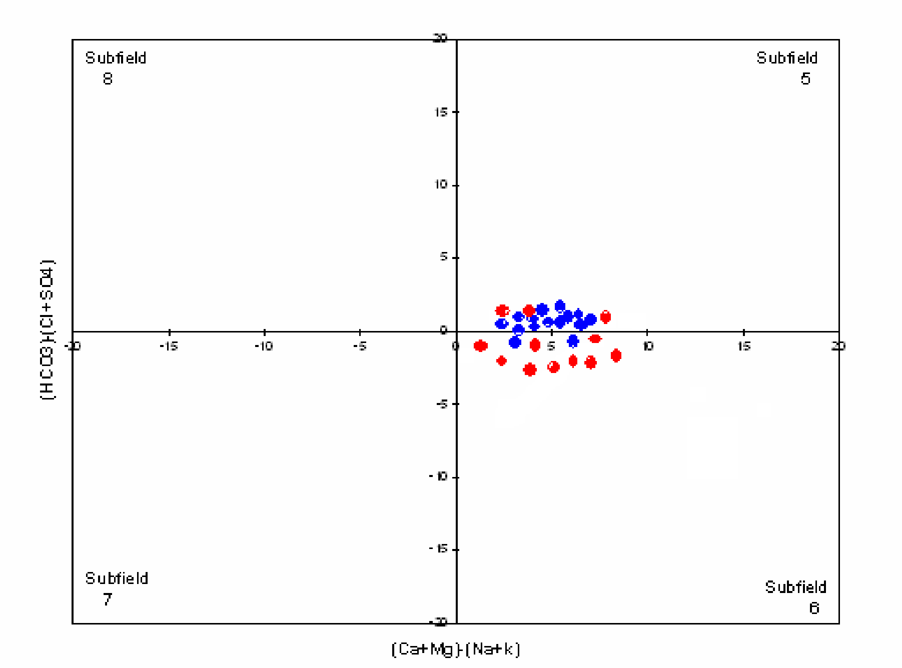

Fig. 2 Classification of Groundwater samples as Per Chadha’s (1999) Scheme

The analyzed data has been plotted on Chadha's (1999) diagram. It has all the advantage on the diamond shaped field of the Piper's trilinear (1953) and can be also used to study various hydro-chemical processes such as base cation exchange, actual ion concentration, mixing of natural waters and sulphate reduction and other related hydro-chemical problems. In the study area; out of 30 groundwater samples,11 sandstone samples and 8 shale samples fall in the subfield -5 of Ca-Mg-HCO_3 type whereas 2 sandstone samples and 9 shale samples fall in the subfield 6 indicating Ca-Mg-Cl-SO_4 type (Fig. 2).

4.1 Pollution Susceptibility

For the estimation of pollution susceptibility. DRASTIC modelling proposed by Aller et al. (1987) has been adopted. The DRASTIC approach takes into account seven hydrogeologic parameters which influence pollution of the area. The index of vulnerability is computed through multiplication of the value attributed to each parameter by its relative weight, and adding up all seven products,

$$\text{DRASTIC INDEX} = 5 \times D + 4 \times R + 3 \times A + 2 \times S + 1 \times T + 5 \times 1 + 3 \times C$$

If D.I.>199, Very high; Between 160 and 199, High; Between 120 and 159, Intermediate; Lower than 120, Low pollution susceptibility.

The various parameters are discussed below:

(i) Depth to Water Table

In the unconfined aquifers of the area, the water table varies between 02 to 10 meters, hence the rating should be between 02 to 08 in sandstone and 08to 10 in shale and the weight parameter is 05.

(ii) Net Recharge

It indicates the amount of water per unit area of land that penetrates the ground surface and reaches water table. The assigned weight for this parameter is 4. The net recharge in the area as determined by the water table fluctuation method is. The rating for this recharge is 3.

(iii) Aquifer Media

The bedding planes, joint planes and fractures developed in sandstones and shale. Primary porosity and permeability are insignificant. The rating may be assigned a value of 2 to7 in sandstone and 08 to 10 in shale. The ratings for aquifer media depend upon the type of consolidated and unconsolidated medium which serves as an aquifer.

(iv) Soil Media

The weight assigned to this parameter is 2. Thickness and types of soils in the area vary from place to place. There are areas where soil thickness is negligible while in others it goes up to 2 meters. The soil type varies from sandy loam to salty or clayey loam. Hence ratings may be taken as 10, 6, 5 and 4 for computing pollution index.

(v) Topography

The hilly tracts have slopes greater than 20 for which the rating is 01. However, in most places have slopes varying between 2 to 6 degrees for which the rating may be 10 in sandstone and shale and assigned weight for this parameter is 01.

(vi) Impact of Vadose Zone

The material present in this zone either facilitate pollution are helps in its attenuation. It also controls the time and distance taken by the pollutants to reach the zone of saturation. In the area, the vadose zone is mainly composed shales and sandstone. Jointing and fracturing are present in rocks. For this the rating may be 3 for shale and 6 for jointed sandstone and assigned weight is 5.

(vii) Hydraulic Conductivity of the Aquifer

It refers to the ability of the aquifer to transmit water under a given hydraulic gradient. The rate of flow within an aquifer controls the movement of contaminants from one place to another.

From the computed values, it is observed that the DRASTIC Index varies between 122 to 151 in sandstone aquifer whereas 124 to 197 in shale aquifer (Table 4). The values suggest the sandstone aquifer have intermediate pollution susceptibility whereas shale aquifer is highly susceptible to pollution.

4.2 Conclusion

The hydrochemical analysis of the study reveals that the groundwater in the study area is moderately hard to very hard and alkaline in nature. The Ca-Mg-HCO_3 and Ca-Mg-Cl-SO_4 are main facies present in the area. The higher values of electrical conductance in shale aquifer may be due to enough time for reaction between groundwater and impervious shale whereas sandstone aquifer has comparatively lesser amount of EC is due to its hydrological characters. The samples exceed the desirable limit of total dissolved solids may cause gasterointestinal problem. The concentration of sulphate associated with shale aquifer is high due to gypsum ($CaSO_4.2H_2$) and baryte ($BaSO_4$) nodules present in shale. The source of high nitrates in groundwater seems to be nitrogen rich fertilizer and pesticides and insecticides used by the farmers in their crops. The contineous intake of high nitrate may cause carcinogenic diseases in human body in near future. Denitrification process may be ineffective due to deeper aquifers in the study area. So by involving agriculture experts and NGOs and creating awareness among farmers about the optimum use of chemical fertilizers as well as maximum use of biofertilizers, the problem can be minimized. The defluoridation and ion exchange technique is suggested in the high flouride locality. The composition of analyzed data with the standard limits recommended by World Health Organization (1984) and Indian Standard Institute (1991) reveals that the groundwater in general, is suitable for drinking purpose.

The computed Drastic Index varies between 122 to 151 in sandstone aquifer whereas 124 to 197 in shale aquifer. In the high pollution susceptibility zone, the unused or dry dug wells should not be used as dumping pits by the nearly habitants and the waste materials should be managed properly.

Table 4 DRASTIC INDEX (pollution potential) of the study area.

Lithology	Location Weightage	Depth to water table 5	Recharge 4	Aquifer Media 3	Soil Media 2	Topography 1	Impact of vadose zone 5	Hydraulic conductivity 3	Total Drastic Number
SSt./1	JAWA	6x5=30	6x4=24	6x3=18	5x2=10	10x1=10	3x5=15	6x3=18	125
SSt./2	BHAKHAR WAR	5x5=25	3x4=12	7x3=21	7x2=14	10x1=10	5x5=25	5x3=15	122
SSt./3	JHALWA	8x5=40	5x4=20	5x3=15	5x2=10	10x1=10	3x5=15	5x3=15	125
SSt./4	BELGAWA	6x5=30	3x4=12	6x3=18	8x2=16	10x1=10	6x5=30	6x3=18	134
SSt./5	SANTITEER	6x5=30	6x4=24	9x3=27	10x2=20	9x1=9	3x5=15	7x3=21	146
SSt./6	AKAURI	8x5=40	5x4=20	5x3=15	5x2=10	10x1=10	3x5=15	6x3=18	128
SSt./7	CHANDI	8x5=40	5x4=20	7x3=21	6x2=12	10x1=10	3x5=15	8x3=24	142
SSt./8	MAHILO	8x5=40	6x4=24	6x3=18	6x2=12	9x1=9	3x5=15	6x3=18	136
SSt./9	INTOURI	6x5=30	3x4=12	6x3=18	8x2=16	10x1=10	6x5=30	6x3=18	134
SSt./10	BARAULI	8x5=40	5x4=20	6x3=18	6x2=12	10x1=10	3x5=15	8x3=24	139
SSt./11	GARHWA	6x5=30	6x4=24	7x3=21	9x2=18	9x1=9	5x5=25	8x3=24	151
SSt./12	ANDWA	8x5=40	5x4=20	5x3=15	5x2=10	10x1=10	3x5=15	6x3=18	128
SSt./13	RAMBAG	6x5=30	6x4=24	7x3=21	8x2=16	10x1=10	5x5=25	8x3=24	150
Sh./14	SHIVPUR	7x5=35	6x4=24	6x3=18	6x2=12	10x1=10	3x5=15	6x3=18	132
Sh./15	PATERI	6x5=30	6x4=24	7x3=21	9x2=18	10x1=10	5x5=25	8x3=24	152
Sh./16	SITALAHA	5x5=25	3x4=12	7x3=21	8x2=16	10x1=10	5x5=25	5x3=15	124
Sh./17	NAGWA	9x5=45	6x4=24	9x3=27	6x2=12	10x1=10	4x5=20	8x3=24	162
Sh./18	BHUNGEON	8x5=40	7x4=28	8x3=24	6x2=12	10x1=10	6x5=30	8x3=24	168

Lithology	Location Weightage	Depth to water table 5	Recharge 4	Aquifer Media 3	Soil Media 2	Topography 1	Impact of vadose zone 5	Hydraulic conductivity 3	Total Drastic Number
Sh./19	DONDOW	9x5=45	9x4=36	8x3=24	7x2=14	10x1=10	8x5=40	8x3=24	193
Sh./20	DAGDAIYA	10x5=50	6x4=24	9x3=27	6x2=12	10x1=10	4x5=20	8x3=24	167
Sh./21	CHANDI	7x5=35	7x4=28	8x3=24	6x2=12	10x1=10	6x5=30	8x3=24	163
Sh./22	KONIYA	9x5=45	9x4=36	8x3=24	7x2=14	9x1=9	8x5=40	8x3=24	192
Sh./23	BHIATARI	10x5=50	6x4=24	10x3=30	8x2=16	10x1=10	6x5=30	10x3=30	197
Sh./24	KUTHILA	9x5=45	9x4=36	10x3=30	8x2=16	10x1=10	6x5=30	10x3=30	197
Sh./25	BASREHI	8x5=40	7x4=28	8x3=24	6x2=12	10x1=10	6x5=30	8x3=24	168
Sh./26	GANJ	10x5=50	6x4=24	9x3=27	6x2=12	10x1=10	4x5=20	8x3=24	167
Sh./27	JONHA	9x5=45	9x4=36	10x3=30	6x2=12	10x1=10	8x5=40	8x3=24	197

References

Ackah M, Agyemang O, Anim AK, et al. 2011. Assessment of groundwater quality for drinking and irrigation: the case study of Teiman-Oyarifa Community, Ga East Municipality, Ghana. Proceedings of the International Academy of Ecology and Environmental Sciences, 1(3-4): 186-194

Aller L, Petty R, Lehar JH, et al. 1987. DRASTIC- A standardised system to Evaluate Groundwater Pollution Potential using Hydrogeological settings. Journal of the Geological Society of India, 29: 23-37

APHA. 1998. Standard Methods for the Examination of Water and Wastewater (14th edition). American Public Health Association, Washington, USA

Babu P, Bhai HY, Sinha M, et al. 2007. Nitrate Contamination in groundwater in Maregaon Taluka, Yavatmal District. Gondwana Geological Magazine (Special), 11: 107-111

Bhartiya KG, Agrwal AK. 2004. High values of nitrates and chloride in groundwater and their possible source in parts of Chhotanagpur granite gneiss comples: A case study from cast and west Singbhum and Saraikela districts. Jharkhand.Geology Survey of India (Special Publication), 83: 299-305

Chadha DK. 1999. A proposed new diagram for geochemical classification of natural waters and interpretation of chemical data. Hydrogeology Journal, 7: 431-439

Chatterjee A, Roy RK, Ghosh UC, et al. 2008. Fluorude in water in parts of Raniganj Colfield, West Bengal. Current Science, 94: 309-311

Duraiswamy RA, Patankar V. 2011. Occurrence of floride in the Drinking Water sources from Gad River, Basin, Maharashtra. Journal of the Geology Society of India, 77: 167-174

ISI. 1991. Indian Standard Specification for Drinking Water. IS:10500, Indian Standard Institution, India

Jasrotia AS, Singh R. 2007. Hydrochemistry and groundwater quality around Devak and Rui watershed of Jammu Region, Jammu and Kashmir, Journal of the Geological Society of India, 69: 1042-1054

Karanth KR. 1987. Groundwater Assessment Development and Management. McGraw Hill Publishing Company Ltd., New Delhi, India

Madhnure P, Sirsikar DY, Tiwari AN, et al. 2007. Occurence of fluoride in the groundwaters Pandharkawada area, Yawatmal district, Maharastra, India. Current Science, 92(5): 675-679

Mishra U. 2010. Hydrogeological Studies of Sirmour Area, Rewa District, Madhya Pradesh. Ph.D. Thesis, A.P.S. Univ. Rewa, M.P., India

Pawar NJ, Shaikh IJ. 1995. Nitrate pollution of groundwaters from shallow aquifers, Deccan Trap Hydrologic Provinces, India. Environmental Geology, 25: 197-204

Pecheco J, Martin L, Gabrcra A, et al. 2001. Nitrate temporal and spatial pattern in 12 water supply wells Yocation, Mexico. Environmental Geology, 40(6): 708-715

Piper AM. 1953. A Graphic Procedure in the Geochemical Interpretation of Water Analysis. U.S.G.S. Ground Water Note 12

Raghunath HM. 1987. Ground Water (2^{nd} edition). Wiley Eastern Ltd., New Delhi, India

Sawyer CN, McCarty PL. 1967. Chemistry for Sanitary Engineers (2^{nd} edition). McGraw Hill, New York, USA

Saxena VK, Ahmed S. 2001. Dissolution of fluoride in groundwater. A water-rock interaction study. Environmental Geology, 40: 1084-1087

Sayyed MRG, Sayadi MH. 2011. Variations in the heavy metal accumulations within the surface soils from the Chitgar industrial area of Tehran. Proceedings of the International Academy of Ecology and Environmental Sciences, 1(1): 36-46

Sayyed MRG, Wagh GS. 2011. An assessment of groundwater quality for agricultural use: a case study from solid waste disposal site SE of Pune, India. Proceedings of the International Academy of Ecology and Environmental Sciences, 1(3-4): 195-201

Tiwari RN, Singh AK. 2010. Groundwater quality and pollution potential of Mahana River Basin, Rewa District, Madhya Pradesh, India. Proceedings of the International Conference on Hydrology and Watershed. JN&T Hyderabad, India

Tiwari RN, Bharti SL, Mishra U. 2010. Hydrogeochemical Studies of Groundwater from Odda River Basin, Rewa District, Madhya Pradesh. Gondwana Geological Magazine (Special), 12: 85-93

Tiwari RN, Dubey DP, Bharti S.L. 2009. Hydrogeochemistry and groundwater quality in Beehar River Basin, Rewa district, Madhya Pradesh, India. Inter. Jour. Earth Eng. Sci., 2(4): 324-330

WHO. 1984. Guidelines to Drinking Water Quality. World Health Organisation, Geneva, Swizerland

Zhang WJ, Jiang FB, Ou JF. 2011. Global pesticide consumption and pollution: with China as a focus. Proceedings of the International Academy of Ecology and Environmental Sciences, 1(2): 125-144