RESEARCH ARTICLE

SAMRIDDHI Volume 13, Issue 2, 2021 Print ISSN : 2229-7111 Online ISSN : 2454-5767

Analysis of Ground Water Quality Using Spatial Techniques in Naya Raipur Atal Nagar, Chhattisgarh, India

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Abstract

Water quality is important for understanding the water suitability in the case of drinking and irrigation practices. According to the various water quality parameters, the groundwater suitability for drinking and irrigational purposes is evaluated in Naya Raipur, Atal Nagar Chhattisgarh. The water quality analysis were conducted on 28 randomly collected ground water samples from dug and bore wells, during pre-monsoon season, better understand how geochemical processes affect groundwater quality. Average order of abundance of quality parameters in the water samples is HCO3> Cl> Ca> Na> Mg> SO4> K> F> Fe. Most of the dug well and borewell samples collected from study area are Ca-Mg-HCO3 type. Based on WQI values, it is inferred that water of most of the villages bears excellent to good category for drinking quality. In addition; different chemical indices (SAR, RSC, MH, KI) suggest that this water is moderately hazardous to agriculture.

Keywords: Ground water, Major ion chemistry, quality of water indices for irrigation, geochemical facies, India.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, (2021); DOI : 10.18090/samriddhi.v13i02.9

Introduction

Human activities have posed an increasing threat to groundwater quality in current years; so, it has become essential to regularly monitor groundwater quality. In India, and particularly in Chhattisgarh, ground water is heavily used for agricultural and industrial activities in addition to drinking purpose. A variety of land and water-based human activities pollute this valuable resource. The ground water quality is critical in determining whether the ground water is suitable for various uses (public water supply, irrigation, industrial applications, power generation etc) or not. There are currently several methods for monitoring the hydro-geochemical processes that cause groundwater contamination. Among these, graphical methods and interpreting various indices have been widely used [1-4].

Water quality can be classified according to its physicochemical and hydro-geochemical properties. The quality of groundwater varies from location to location, with the water table depth, and from season to season, and is primarily governed by the quantity and composition of dissolved solids present in it. The current study focuses on the physicochemical characteristics of ground water parameters in the study area. The analysed data were compared with WHO-recommended standard values.

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How to cite this article : Das, B., Panigrahi, K., Patel, B. (2021). Analysis of Ground water Quality Using Spatial Techniques in Naya Raipur Atal Nagar, Chhattisgarh, India.
SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, Volume 13, Issue (2), 109-117.
Source of support : Nil
Conflict of interest : None

Study Area

Naya Raipur Atal Nagar is a newly developing township in Chhattisgarh, located about 17 kilometres southeast of the Raipur city and it covers an area of about 80 square kilometres (8000 hectares). Geographically, the study area is bounded by coordinates from 21° 5' 37" N to 21° 13' 38" N and 81° 43' 20" E to 81° 50' 34" E and is covered by SOI toposheet no. 64G/12 (Figure 1). The study area experiences subtropical climate with intense summer and mild winter seasons. Summer lasts from March to May, with April and May being the hottest months. The rainy season lasts from June to September, with rainfall evenly distributed due to the southwest monsoon. The monsoon season normally starts in the third week of June and peaks in July and August. During the months of December and January, the weather is dry and cold, with only occasional shower**.**

Geological Settings

The study area is mainly covered by the rocks of Raipur Group, which belongs to unmetamorphosed and undeformed Chhattisgarh Supergroup deposited in Baradwar sub-basin, having carbonate (both stromatolitic and non stromatolitic limestone and dolomite) dominated litho succession with shale and minor sandstone units formed in varied environment [5].

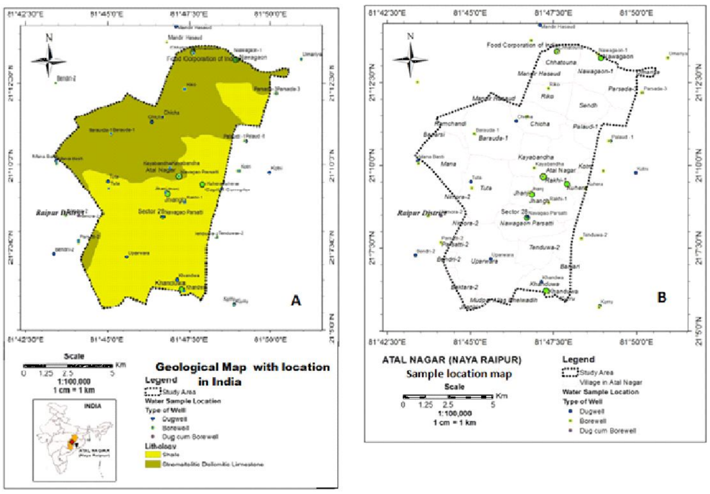

Figure 1(A) : Geological map of the area showing location in India (inset)

Figure 1(B): Sample location map.

Litho-stratigraphically the Raipur Group in study area is represented by Gunderdehi Shale and Chandi Limestone Formations (Figure 1A). The south most portion of the study area covered by Gunderdehi shale. The rock formations of the Raipur Group are predominantly limestone and dolomite, which represents one of India's most important carbonate aquifer systems [6].

Materials and Methods

Sampling and Analysis

A total of 28 ground water samples were taken from dug wells, bore wells and hand pumps during the post-monsoon period of 2020-2021, and were stored and analysed following the guidelines [APHA-2320, 1999]. Different geological formations, land use characteristics, accessibility and permission for taking samples from certain households and aquifer depths were the key attributes used for groundwater sampling**.** The sampling locations are given in Figure 1. B.

In the current study, Electrical conductivity and hydrogen ion concentration as pH were determined at the time of sample collection before sealing the sample container, while other ionic components were analysed at Centre for Ground Water Recharge Testing Laboratory, Raipur, as per the APHA-AWWA-WEF (1995) guidelines. All the chemical parameters are expressed in mg/l, except that of EC which is in µs/cm and data are presented in Table–1.

Table-1: Chemical Analysis of water samples from study region (Naya Raipur) Post monsoon

S. No.	VILLAGE NAME	Sample ID	pH	Turbidity	Conductivity	TDS	TH CaCO3	Ca^{++}	Mg^{+}	CL^{-}	M - Alkalinity HCO_3	F	Sulphate as SO_4	Fe	Nitrate NO_3	Na mg/l	K
1	KHANDUWA	DW-01	7.29	0.21	540	280	164	60.92	2.91	73.16	153	0.1	47.861	0.09	0.21	33	2
2	NIMORA-2	DW-02	7.32	0.19	1300	710	324	94.58	21.38	179.26	213	0.6	51.985	0.2	0.32	51	30
3	BENDRI-2	BW-01	6.9	0.16	1100	580	544	102.6	69.98	159.14	216	0.09	28.513	0.1	0.72	36	5
4	PARSATTI-2	BW-02	7.44	0.18	490	260	180	79.95	16.52	38.41	189	0.09	6.692	0.1	0.68	16	1
5	MANA	DW-03	6.92	0.19	720	380	240	68.93	16.52	115.24	123	0.09	43.623	0.1	0.31	37	21
6	TUTA	BW-03	7.02	0.19	510	270	152	35.27	15.55	7.31	54	0.09	4.9	0.09	0.24	24	12
7	KURRU	DW-04	6.82	0.2	360	190	180	56.11	9.72	5.48	159	0.09	4.9	0.09	0.14	10	1
8	KURRU	BW-04	6.24	0.22	560	300	140	40.08	9.72	84.14	75	0.09	13.48	0.09	0.27	32	12
9	PACHEDA-2	DW-05	6.85	0.18	510	270	240	64.12	19.44	7.31	330	0.09	4.9	0.09	0.98	20	2
10	BARAUDA-1	BW-05	7.58	0.21	390	210	204	20.84	36.93	25.6	210	0.12	9.32	0.09	0.22	23	2
11	CHICHA	DW-06	7.33	0.24	90	50	16	0.49	0.49	91.46	54	0.09	0.69	0.09	0.12	5	2
12	RIKO	BW-06	6.96	0.22	800	420	256	86.57	9.72	120.72	180	0.17	12.36	0.19	3.23	29	4
13	KAYABANDHA	DW-07	6.93	0.32	700	370	152	40.08	12.63	47.55	207	0.23	6.32	0.12	1.97	25	12
14	KAYABANDHA	BW-07	6.27	0.19	370	200	172	44.88	14.58	36	195	0.09	4.98	0.09	0.17	11	1
15	JHANJ	DW-08	6.27	0.22	940	500	368	88.17	35.96	197.55	99	0.36	17.28	0.23	2.74	39	18
16	RAKHI-1	BW-08	7.25	0.19	430	230	180	62.52	5.83	78.65	99	0.09	4.97	0.09	0.92	23	6
17	NAWAGAON PARSA	DW-09	6.47	0.23	460	260	120	33.66	8.75	58.66	123	0.09	9.36	0.09	0.65	25	4
18	NAWAGAON PARSA	BW-09	7.34	0.19	500	260	208	68.93	8.75	53.04	168	0.21	8.93	0.09	0.69	19	2
19	TENDUWA-2	BW-10	6.96	0.23	560	300	276	72.14	23.33	42.07	267	0.09	12.23	0.09	0.68	26	2
20	KUHERA	BW-11	7.43	0.22	640	340	164	38.47	16.52	64.02	309	0.32	17.23	0.17	0.81	56	6
21	RAKHI-1	DW-10	7.11	0.23	1690	900	796	267.7	31.1	382.3	189	0.68	26.36	0.25	2.79	26	9
22	RAKHI-1	BW-12	6.89	0.19	1160	630	500	162.1	21.38	226.82	219	0.53	21.32	0.29	2.15	26	5
23	PALAUD-1	BW-13	7.66	0.22	470	250	100	24.04	9.72	62.21	156	0.09	9.32	0.09	1.03	41	2
24	MANDIR HASAUD	DW-11	7.42	0.23	530	280	156	49.69	7.77	65.85	201	0.09	8.36	0.09	0.56	26	1
25	MANDIR HASAUD	BW-14	7.05	0.21	680	360	220	80.16	4.86	87.8	213	0.23	7.79	0.17	0.94	26	1
26	CHHATOUNA	BW-15	7.07	0.36	690	370	276	70.54	24.3	106.09	215	0.32	7.36	0.09	0.35	40	2
27	UMARIYA	BW-16	7.55	0.23	770	410	320	86.57	25.27	78.65	315	0.23	17.23	0.14	0.39	34	6
28	PARSADA-3	BW-17	7.98	0.22	980	520	420	128.3	24.3	153.65	207	0.32	19.36	0.23	5.98	35	7

RESULTS

Physicochemical analysis

The physico-chemical characteristics of parameters is determined in ground water samples have been statistically analysed and their values are compared with Bureau of Indian Standard (2012) and WHO (1993 [7,8]) assigned permissible limits (Table – 2), to have a ready assessment of the ground water suitability of study area, for drinking use. However, no significant changes are observed in the concentration of these parameters from Dug-well and Bore-well samples (Figure 2), implying least impact of contamination. The distribution patterns of these parameters are discussed below:

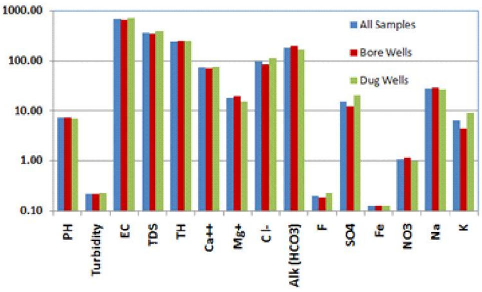

Figure 2: Bar diagram comparing variation in concentrations of cations and anions in Bore wells, dug wells all sample.

Table-2: Averages of analyzed groundwater data compared with WHO (1993)

	Min.	Max.	Average	WHO	BIS Desirable	BIS Maximum
pH	6.27	7.98	7.08	7.0 -8.0	6.5 -8.5	No Relaxation
Turbidity	0.16	0.36	0.22	-	1	5
EC	90	1690	676.43	-	>1000	3200
TDS	50	900	360.71	1000	500	2000
TH	16	796	237.43	100	200	600
Ca	0.49	267.7	72.44	76	75	200
Mg	0.49	69.98	18	30	30	100
Cl	7.31	382.3	94.58	250	250	1000
HCO3	54	330	183.5	-	200	600
F	0.09	0.68	0.2	1	1	1.5
SO4	0.69	51.98	15.27	250	200	400
Fe	0.09	0.29	0.13	0.1	0.3	No Relaxation
NO3	0.12	2.79	1.08	50	45	No Relaxation
Na	5	56	28.36	200	-	-
K	1	30	6.36	-	-	-

pH

Based on the Bureau of Indian Standard (2012) and WHO (1993), the pH limit for water which can use for drinking purpose, is 7.0–8.5 and 6.5–8.5, respectively. The samples were collected from study area shows, pH of 6.27 to 7.98, with a mean value of 7.08. However, the water samples of villages Kurru (BW), Kayabandha (BW), Jhanj (DW), and Nawagaonparsa (DW) record pH values slightly below 6.5, indicating their slightly acidic nature, whereas the remaining samples shows desirable pH range (Table 2).

Total Dissolved Solids

In our water samples, the TDS values range from 50 to 900 mg/l and the mean value is 360.71 mg/l

(Table 2). The TDS value of almost all villages is recorded less than 300 mg/l, suggestive of excellent nature of drinking water. Whereas in villages, Bendri-2, Mana, Riko, Kayabandha(DW), Jhanj, Kuhera, Mandir Hasaud (BW), Chhatouna, Umariya and Parsada-3 TDS values range between 400 and 600 mg/l. and in villages, Nimora-2 and Rakhi-1 TDS values are recorded as 700 and 900. Based on the TDS content it is inferred that these water samples fall in very good to fair limits drinking water.

M-Alkalinity

In groundwater alkalinity is caused by dissolved carbon dioxide, carbonate, and bicarbonate. The alkalinity of the sampled region varies between 54 and 330 mg/l, which is within acceptable limits (WHO, 2003; BIS, 2012) (Table 2) [7,9].

Total Hardness

The key cause of hardness in water is the presence of divalent cations (Ca and Mg). Scale formation occurs when the total hardness of the sample exceeds 200 mg/l. According to the BIS standard, the appropriate limit is 200 mg/l and the permissible limit of hardness is 600 mg/l. The concentration of hardness in the study area varies 16 to 796 mg/l and the mean value is 237.43 mg/l. According to BIS guidelines, the majority of samples in this area have concentrations above the appropriate level, which is 200 mg/l (Table 1).

Calcium

The ground water samples taken from the study area has Ca concentration of 0.49 to 267.7 mg/l. In most of the samples Ca concentration is within the maximum permissible limit (BIS: 75 -200 mg/l) except village Rakhi, where Ca is observed above permissible limits (Table 2). Carbonate minerals such as calcite and dolomite and clay minerals are the key calcium source in the study region.

Magnesium

As per BIS (2012) and WHO (1993 [7,8]), the concentration of magnesium ion in the study area is below the desirable limit in all samples, which varies from 0.49 to 69.98 mg/l (Table 2).

Chloride

The Cl concentration in groundwater is mainly from natural sources and human activities (WHO, 1993 [8]). BIS (2012) has given the permissible range of Cl ion in water as 200 to 1000mg//l. The concentration of chloride in the ground water samples taken from the study area ranges from 7.31 to 382.30 mg/l (Table 2). Except village Rakhi, where Cl concentration in Dug well (382.30 mg/l) and Borewell (228.92 mg/l) is above permissible limit, all other villages show Cl values below the permissible limit. Agricultural runoff, road salting and waste water from wastewater treatment plants are all sources of chloride in water. Chloride levels in the water are commonly used as a pollution indicator and as a tracer for groundwater contamination.

Sodium

In the study area sodium concentration is vary from 5 to 56 mg/l, and has a mean value of 28.35 mg/l (Table 2). Sodium content in almost all samples is within acceptable limits (WHO,1993) An accumulation of sodium ions in water can cause increase in blood pressure and toxaemia in pregnant women (Haritash et al. 2014).

Potassium

A potassium level in the study region varies from 1 to 30 mg/l, and has mean value of 6.35 mg/l, (Table 2). WHO (1993) recommended potassium level of 200 mg/l as the maximum permissible limit. Therefore all the villages in this region fall in the safe zone.

Iron

Based on BIS (2012) guidelines, Fe concentrations in drinking water should not exceed 0.3 mg/l. In the study region Iron ranges from 0.09 to 0.29 mg/l, and all the samples in this region have concentrations well under permissible limits (0.3 mg/l), making them fit for drinking purpose.

Flouride

The appropriate limit is 1.0 mg/l, and the allowable limit is 1.5 mg/l, according to WHO and BIS. Fluoride concentrations in the study region range from 0.1 to 0.68 mg/l, (Table 2) and all groundwater samples have fluoride values below the appropriate level.

SO_4

Based on the Bureau of Indian Standard [7] (2012) guideline, the appropriate limit is 200 mg/l and the allowable limit is 400 mg/l. Sulphate concentrations in the sample region range from 0.69 to 51.98 mg/l. The majority of ground water samples taken from the research areas have sulphate concentrations that are below the safe level (Table 2).

DISCUSSION

Water Quality Criterion for drinking purpose.

Water quality criterion convey the overall water quality (whether it is suitable for drinking purposes or not) of any samples under investigation. Due to its usefulness for understanding the quality of water, it has become a common practice to determine and track the water quality [10-12].

Water Quality Index (WQI) Analysis

Water quality index is computed using analysed chemical parameters of the ground water samples (Table 1). This index readily determines the drinking water quality.

The WQI is calculated in three steps as follows

Initially, each of the 11 parameters (pH, TH, Ca_2^+, Mg_2^+, Cl, HCO_3, TDS, F, NO_3, SO_4, and Fe) was given a weight (w_i) based on relative importance of overall quality of drinking water [13, 14].

In the second stage, using this equation the relative weight (W_i) is computed

$$W_i = \frac{w_i}{\sum_{i=1}^{n} wi}$$

wi is represents the weight of each parameter, n represents the number of parameters and (Wi) is the relative weight. The values of weight (w_i), and the calculated relative weights (Wi) are given in Table 3.

Using the below equation, quality rating scale (q) is computed for every parameters in third step:

$$q_i = \frac{C_i}{S_i} \times 100$$

Here q_i is the quality ranking, Ci is each parameter's concentration in each water sample, and Si is the WHO standard for each parameter in mg/l. Calculations of WQI is done by first determining the S_i for each parameter using equation (1), followed by calculation of WQI according to equation (2).

$$SI_i = W_i \times q_i \quad (1)$$

$$WQI = \text{“} SI_i \quad (2)$$

In reference [15], authors have classified ground water in to five categories on the basis of above computed WQI values. These are very good, good, poor, very poor and unsuitable for human consumption. Based on quality index data (Table 4), the groundwater of most of the villages have excellent drinking water quality; while that of Nimora, Rakhi-1 and Palaud-1bear good quality of drinking water.

Table-3: Relative weights of chemical parameters

Chemical Parameters	Indian Standards	Weight (wi)	Relative weight (Wi)
pH	6.5- 8.5	4	0.108
TH	300 -600	2	0.054
Ca	75 -200	2	0.054
Mg	30 -100	2	0.054
Cl	250 - 1000	3	0.081
HCO3	244 -732	3	0.081
TDS	500 -2000	4	0.108
F	1 -1.5	4	0.108
SO4	200 - 400	4	0.108
Fe	0.3 -1.0	4	0.108
NO3	45 - 100	5	0.135
		∑wi=37	∑ Wi =0.999

Feasibility of Water for Irrigation

Various indices and criterion have been proposed to assess the feasibility of groundwater for agricultural purposes. Among these Sodium Absorption Ratio (SAR) values, Kelly Index, Magnesium Hazards and Residual Sodium Carbonate (RSC) are important [16,17]. The Magnesium Hazard and RSC are important, as these indices are helpful in ascertaining the alkalinity and permeability behaviour of the soil. So, the groundwater is suitable for irrigation purpose.

Sodium Absorption Ratio (SAR)

The sodium absorption ratio was introduced by the Salinity laboratory of US Agricultural department to indicate sodium absorption by soil [16, 18], and the value is mainly controlled by the content of dissolved sodium in water. SAR is computed by the formula

$$\mathbf{SAR = Na^+ / \text{”}(Ca^{+2}+Mg^{+2})/2}$$

The increasing concentration of salt in water leads to the saline soil formation, which causes the development of alkaline soil. Based on SAR values, water is classified into low (SAR <6), medium (SAR 6–12), high (SAR 12–18), and very high (SAR >18) alkali water. The SAR values of this region range from 1.74 to 10.67. At Kuhera village SAR value is higher than 10 in water sample, which indicates its medium alkaline nature which is suitable for textured or organic soil with good permeability (Table 4). Whereas waters of all other villages having low alkaline water are excellent for agricultural purpose.

Residual sodium carbonate (RSC) for irrigation : High RSC water is considered to be deleterious to the physical properties of the soils, leading to a decrease in soil permeability (Source. IS: 1624-1986). RSC is defined by the formula:

$$RSC = (CO_3^{-} + HCO_3^{-}) - (Ca^{++} + Mg^{++})$$

The RSC values in ground water samples vary from 0.855 to 5.365 meq/l. The groundwater of the study area having RSC < 2.94 are medium hazardous, while those samples having RS in the range of 3.16 to 5.365 are categorized as highly hazardous for irrigation (Table-4).

Magnesium Hazards (MH) : The higher amount of magnesium in ground water can degrades soil quality, resulting in lower agricultural yields. Magnesium hazard is calculated by the formula:

$$MH = Mg^{2+} \text{“}100\ (Ca^{2+} + Mg^{2+})$$

The MH values greater than 50 in groundwater is considered as hazardous and unfit for irrigation [19]. The MH values in this region vary from 5.71 to 63.92, with a mean of 22.09 (Table-4). Based on the MH values, the sample collected from Barauda-1 is moderately hazardous for irrigation, while other excellent for irrigation.

Kelly Index : Kelley (1940) proposed an index defined by the ratio of Na to Ca + Mg, which is used for classification of water for irrigation purpose. Kelly index value <1.0 is suggestive of suitability for irrigation [17]. Kelly index value of study area ranges from 0.142 to 5.102 (Table-4). Based on KI values groundwater of all the villages is suitable for irrigation except that of village Chicha, which is unsuitable.

Hydro-geochemical Facies

The Piper (1944) trilinear diagram and Durov (1948) plot can be used to explain the geochemical evolution of water in general (and groundwater in particular). These diagrams were plotted using Grapher -12 in this analysis. Piper diagram is a multi-dimensional plot in which miliequivalent (meq) percentage concentrations of major cations ($Ca^{2+,}$ Mg^{2+}, Na^{+}, and K^{+}) and anions (HCO^{3-}, SO_4^{2-}, and Cl^{-}) are represents in two triangular fields, which are then projected further into the middle diamond region. The Durov diagram, on the other hand, is a composite plot made up of two ternary diagrams in that the meq percentages of the cations plotted against the meq percentages of the negative ions; the sides form a central rectangular binary plot of total cations vs. total anions concentrations. Water samples having similar qualities will prefer to plot together as groups. Both diagrams show similarities and dissimilarities among ground water samples.

The results of the water analysis in the sampled region are plotted in a piper diagram. The village of Khanduwa, according to the piper diagram, is chlorine bicarbonate rich water, while water samples of the other villages fall in the $Ca\text{-}Mg\text{-}HCO_3$ field (Figure 3). Data present on Durov diagram (Figure 4) shows that the mixed water types predominate in this region. The samples are plotted along with the dissolution or mixing line in the Durov sector. This pattern can be due to infiltration of fresh water in the monsoon time exhibiting simple dissolution or mixing with no dominant major anion or cations, according to Lloyd and Heathcoat (1985). The graphical comparison of our data with Pre-monsoon data [20], in Figure 6, clearly demonstrate a decrease in the content of cations and anions suggesting impact of dilution due to infiltration.

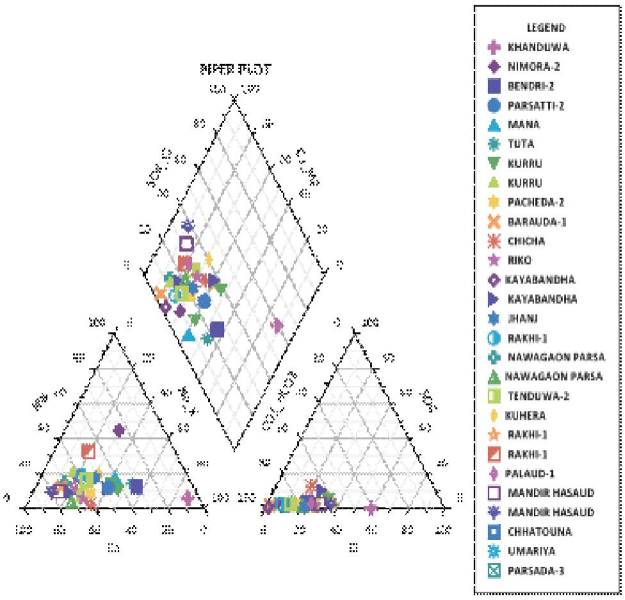

Figure 3: Piper plot indicating dominance of $Ca\text{-}Mg\text{-}HCO_3$ type

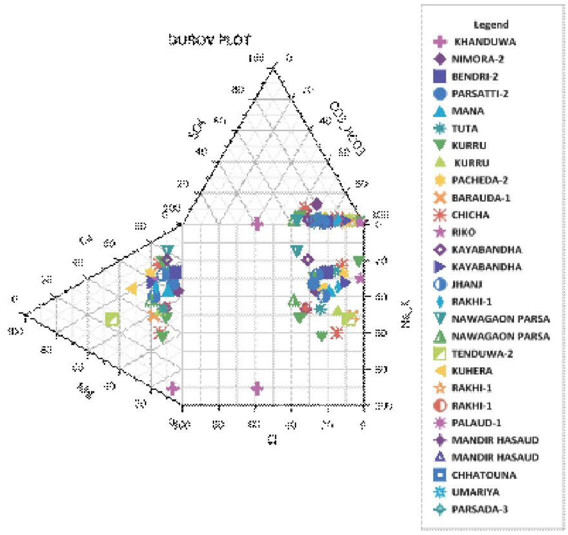

Figure 4: Durov Diagram

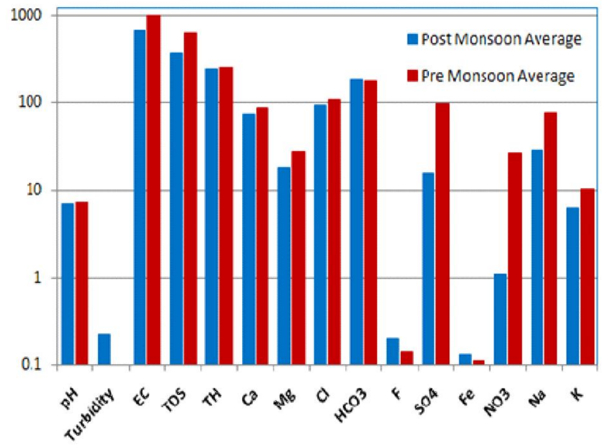

Figure 5: : A significant decrease in the contents of cations and anions is obervedin Post-monsoon (this study) compated to Pre-Monsoon [20], due to dilution.

Table-4: Water Quality Indices of Groundwater from Naya Raipur

Sl. No.	Village	Index for water quality (WQI)	Sodium Absorption Ratio (SAR)	Residual Sodium Carbonate (RSC)	Magnesium, Hazard (MH) meq/l	Kelly Index
1	KHANDUWA	24.340	5.841	2.477	4.559	0.517
2	NIMORA-2	61.381	6.698	3.429	18.437	0.440
3	BENDRI-2	27.719	3.875	3.435	40.549	0.209
4	PARSATTI-2	27.053	2.304	1.314	17.124	0.166
5	MANA	26.231	5.661	1.970	19.333	0.433
6	TUTA	22.617	4.761	0.855	30.598	0.472
7	KURRU	23.420	1.743	2.572	14.765	0.152
8	KURRU	22.433	6.413	1.202	19.518	0.643
9	PACHEDA-2	25.025	3.094	5.365	23.265	0.239
10	BARAUDA-1	26.670	4.279	3.404	63.926	0.398
11	CHICHA	25.872	7.143	1.138	50.000	5.102
12	RIKO	23.781	4.179	2.901	10.095	0.301
13	KAYABANDHA	49.007	4.870	3.365	23.961	0.474
14	KAYABANDHA	35.903	2.017	3.164	24.521	0.185
15	JHANJ	22.605	4.950	1.551	28.970	0.314
16	RAKHI-1	61.874	3.934	1.588	8.530	0.337
17	NAWAGAON	24.071	5.429	1.993	20.632	0.589
18	NAWAGAON	25.532	3.049	2.714	11.264	0.245
19	TENDUWA-2	26.872	3.763	4.324	24.437	0.272
20	KUHERA	24.182	10.680	5.036	30.042	1.018
21	RAKHI-1	48.248	2.127	2.941	10.407	0.087
22	RAKHI-1	77.3963	2.714	3.642	11.651	0.142
23	PALAUD-1	80.525	9.979	2.539	28.791	1.214
24	MANDIR HASAUD	24.741	4.851	3.266	13.522	0.452
25	MANDIR HASAUD	-	3.988	3.449	5.716	0.306
26	CHHATOUNA	39.968	5.809	3.471	25.622	0.422
27	UMARIYA	24.856	4.547	5.102	22.595	0.304

Excellent, Good, Moderately Hazardous, Highly Hazardous, Suitable, Unsuitable

Gibb's Diagram : Gibb's diagram (1970) is critical for understanding the mechanism which can regulate the ground water chemistry (Gibb's, 1970). The processes which regulate the water chemistry are evaporation, condensation and interaction with lithology. Gibbs (1970) suggested two plots: (i) TDS vs. Cl/(Cl+HCO_3), and (ii) TDS vs. (Na+K)/(Na+K+Ca). The majority of samples of this study fall into the rock dominated portion, it is indicating that the rock-water interaction is the major chemical process in the study area (Figure 5) controlling the groundwater contamination.

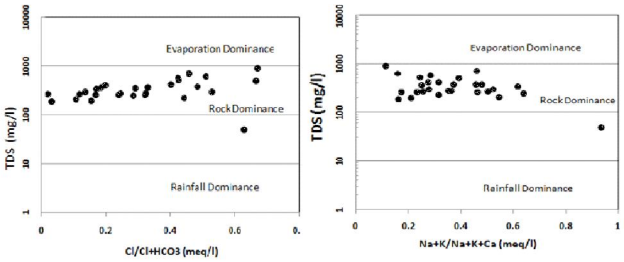

Figure 6: Gibbs plot showing concentration of plots in Rock dominance field, implying ocuurrence of chemical components die to intercation with rocks.

CONCLUSION

To assess the feasibility of ground water for both drinking and irrigation purposes multiple chemical parameters were assessed in the bore well and dug well water samples of Atal Nagar Naya Raipur. Water chemistry of the Atal Nagar Naya Raipur indicates the primary sources from weathering of rocks and their minerals and secondary dominance of human activities. The results of this research in the study area show that the following types of concentration are dominating this region where Na+K 8%, calcium 17 %, magnesium 4%, Sulphate (SO_4) 4%, M-alkalinity 44% and Cl 23 %. The village Khanduwa consists of highly chlorine bicarbonate rich water, in village Tenduwa-2 samples consists of slightly calcium-rich water and all the village of the study area shows shallow fresh groundwater. According to Durove diagram the water composition is dominated by the atmospheric precipitation process. The main source of chemical composition is rock water interaction.

The WQI results show that the ground waters samples of all sites have excellent quality for drinking use, except the sample collected from Rakhi and Palaud where water quality is good for the purpose of drinking. It is presumed that the agricultural wastes, fertilizer used, soil leaching, sewage, livestock waste, and urban runoff have mildly contaminated the groundwater. The total dissolved solids, anions (F^-, Cl^-, and NO_3^-), and positive ions (Mg^{2+} and Na^+) are more responsible parameters for poor water quality for drinking purpose of the study area (Table 4).

Most of the ground water samples in this region are good for irrigation purpose however being moderately hazardous because these samples have hard to very hard hardness. In the village Kuhera the SAR value is more than 10 which indicates medium hazards and remaining villages of the study area shows suitability for irrigation. According to RSC values village pacheda-2, Barauda-1, Kayabandha, Tenduwa-2, Kuhera, Rakhi, Mandir Hasaud, Chhatouna, Umariya and Parsada-3 are highly hazardous for irrigation. According to magnesium concentration, the village Barauda-1 and Chicha sample are unsuitable for agriculture purpose. Based on the Kelly Index the villages Chicha, Kuhera and Palaud-1 samples are unsuitable for agriculture purpose. Based on the above information it is inferred that this water will harmfully affect the growth of plant and it can contaminate the quality of the soil. In general, the major sources of groundwater pollution is the impact of agricultural runoff, anthropogenic activities, ion exchange, and weathering.

REFERENCES

[1] Coetsiers M, Walraevens K (2006) Chemical characterization of the neogene aquifer, Belgium. Hydrogeol J 14(8):1556–1568

[2] Das A, Kumar M (2015) Arsenic enrichment in the groundwater of Diphu, Northeast India: coupled application of major ion chemistry, speciation modeling, and multivariate statistical techniques. CLEAN Soil Air Water 43(11):1501–1513.

[3] Kumar, S., Ghosh, N. C., Singh, R. P., Sonkusare, M. M., Singh, S., Mittal, S. (2015). Assessment of water quality of lakes for drinking and irrigation purposes in Raipur City, Chhattisgarh, India.

[4] Srivastava SK, Ramanathan AL (2008) Geochemical assessment of groundwater quality in vicinity of Bhalswa landfill, Delhi, India, using graphical and multivariate statistical methods. Environ Geol 53(7):1509–1528.

[5] Patranabis-Deb, S. (2004) Lithostratigraphy of the Neoproterozoic Chhattisgarh Sequency, it's bearing on the Tectonics and Paleogeography. Gondwana Res. V. 7(2), pp. 323-337.

[6] Murti, K.S. (1987) Stratigraphy and Sedimentation in Chhattisgarh Basin In Radhakrishna, B.P. (Ed.),

Purana Basins of Peninsular India (Middle to Late Proterozoic). Memoir Geol. Surv. India, 6 :pp. 239-260.

[7] BIS (Bureau of Indian Standard) (2012) 10500, Indian standard drinking water specification, Second revision, pp.1-24.

[8] WHO (1993) (World Health Organization) Guidelines for drinking water quality. 2nd Ed., Vol. 1, p. 18

[9] WHO (2003) World Health Organization Report. Guidelines for drinking waterquality, Geneva, Switzerland.

[10] Mishra PC, Patel R K(2001) study of the pollution load in the drinking water of Rairangpur, a small tribal dominated town of North Orissa. Indian J Environ Ecoplan 5:293-298.Si.

[11] Singh PK, Tiwari AK, Panigarhy BP, Mahato MK (2013) Water Quality Indices used for water resources vulnerability assessment using GIS technique: a review. Int J Earth Sci Eng 6(6-1) : 1594-1600.

[12] Tiwari, K.K., Prasad, R.N., Chandra, R. and Mondal, N.C. (2012) Geochemical parameters for assessment of groundwater quality around urban and suburban areas of Dausa city in Rajasthan, India. Jour. Appld Geochem., v.14(2), pp.184–193.

[13] Srinivasamoorthy K, Chidambaram M, Prasanna MV, Vasanthavigar M, John Peter A, Anandhan P (2008) Identification of major sources controlling groundwater chemistry from a hard rock terrain—a case study from Mettur Taluk, Salem district, Tamilnadu, India. J Earth System Sci 117 (1) :49 – 58.

[14] Ketaka-Rokbani M, Bouhlila R (2011) Use of geographical information system and Water Quality Index to assess groundwater quality in El Khairat Deep Aquifer (Enfidha Tunisian Sahel). Iran J Energy Environ 2(2): 133-144.

[15] Sahu P, Sikdar PK (2008) Hydrochemical framework of the aquifer in and around East Kolkata wetlands, West Bengal, India. Environ Geol 55:823-835.

[16] Todd, K.D. and Mays, M.W. (2013) Groundwater Hydrology, Third Edition.

[17] Kelley WP (1940) Permissible composition and concentration for irrigation water. Proc Am Soc CivEng 66:607-613.

[18] Suarez, D. L. 1981. Relation between pHc and sodium adsorption ratio (SAR) and an alternative method of estimating SAR of soil and drainage waters. SSSA J. 45(3): 469 475.

[19] Szabolcs I, Darab C (1964). The influence of irrigation water of high sodium carbonate content of soils. In: Proceeding of 8th international congress of ISSS, transmission, vol 2, pp 803-812.

[20] Khan R, Jhariya D C 2018 Hydrogeochemistry and Groundwater Quality Assessment for Drinking and Irrigation Purposeof Raipur City, Chhattisgarh. Jour. Geol. Soc Ind. 91: 475-482.