RASĀYAN J. Chem.
Vol. 9 | No. 4 |627 - 633 | October - December | 2016
ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP
http://www.rasayanjournal.com
http://www.rasayanjournal.co.in

CHEMICAL ANALYSIS OF GROUND WATER OF BOLPUR BLOCK, BIRBHUM, WEST BENGAL, INDIA

Sakuntala Chakrabarti[1,*] and Pulak Kumar Patra[2]
[1] Department of Environmental Science, Vivekananda College,
Kolkata-700063, West Bengal, India
[2]Department of Environmental Studies, Visva Bharati, Birbhum-731235, West Bengal, India
*E-mail: sakuntala.vb@gmail.com

ABSTRACT
The purpose of this study is investigating the chemical analysis of ground water in Bolpur block of Birbhum district, West Bengal, India. Altogether 89representative groundwater Samples were collected from deep tubewells, shallow tubewells, supply water and dug wells for each season during April, July and November of 2013 in order to assess its suitability for drinking as well as irrigation purpose and the seasonal variation of water quality during pre-monsoon, monsoon and post-monsoon. The water chemistry of samples were analyzed for pH ,Total Dissolved Solid (TDS), Electrical Conductivity(EC), Sulphate(SO_4^{2-}), Nitrate(NO_3^-), phosphate(PO_4^{3-}), Fluoride(F^-), Calcium(Ca^{2+}), Magnesium(Mg^{2+}), Sodium(Na^+), Potassium(K^+), Bicarbonate(HCO_3^-), carbonate(CO_3^{2-}), Iron(Fe^{2+}) and Total Hardness(TH) using standard techniques. The results revealed that the maximum SAR (Sodium adsorption ratio) in all three seasons was below 1. Maximum % Na was found to be 19.1 which was observed in Pre-monsoon season indicating its suitability for irrigation. But in most of the water samples in Fe^{2+}, EC, Ca^{2+} were above the acceptable limit recommended by WHO and USEPA standards and in some samples NO_3^-, Na^+ and K^+ were found to be elevated. These observations are similar in all three seasons. pH ranged in all the samples within limit (6.5 to 8.5). Based on the findings of this study, it can be expressed that the groundwater quality in Bolpur block is suitable for irrigation but not appropriate for drinking as some of the parameters are elevated and need proper treatment. Although Birbhum district is one of the worstly fluoride affected district in West Bengal the fluoride concentration was within the permissible limit i.e. 1.5 mg/l in all samples for all seasons in this region.
Keywords: Chemical analysis, ground water quality, Bolpur block, Birbhum district, West Bengal, India.

INTRODUCTION

The quality of water is vital for humankind. Water quality gets modified in the course of movement of water through the hydrological cycle and through evaporation, transpiration, and selective uptake by vegetation, oxidation/reduction, cation exchange, dissociation of minerals, precipitation of secondary minerals, mixing of waters, leaching of fertilizers and manure, pollution and lake/sea, biological processes[1]. Poor quality of water adversely affects the human, animal and plant health[2-7]. Ground water quality data is essential to determine the origin of chemical composition of groundwater[8]. The Bolpur block under Birbhum district, West Bengal is predominantly a rural and agricultural area with a significant tribal population. Major industries are absent. Small scale industries are mainly cottage industries, oil mill, rice mill, pottery manufacturing. Thus groundwater quality mainly influenced by lithology and fertilizers used for agricultural purposes (leached with precipitation). The purpose of our present study is to study the groundwater quality of Bolpur area and to evaluate its suitability for drinking and irrigation.

Study area

Bolpur block is located in the western part of west Bengal state along $23^0 40'$ north latitude and $87^0 43'$ east longitude. The Bolpur area spreads over an area of 333.92 sq.km falling within the semi-arid region and facing chronic water scarcity during summer (April-May). Bolpur is one of the most important cultural region of West Bengal and is one of the most important block of Birbhum district. Birbhum is bounded on the north and west by Santhal Paraganas.

Population

This block has a population of 175,490 (2001 census). Bolpur Sriniketan block registered a population growth of 15.42% during the 1991-2001 decade. The density of population is 526/km^2. Bolpur is basically a rural area and is one of the major tribal areas in West Bengal having 34,177 tribal population (2001 census).

Climate

Bolpur block climatologically falls under the western semiarid belt of West Bengal. The summer is severe with an average temperature of 40^{0}C. During the month of May temperature shoots upto 48^{0}C. The average temperature is 11^{0}C in winter, but temperature as low as 8^{0}C is also recorded. This area receives rainfall from mid-June to September and sometimes upto October.

Geology and Groundwater condition

Geology of a region is directly responsible for its groundwater resources. Occurrence, movement and storage of ground water are influenced by lithology, thickness and structure of rock formations. There is no perennial river in the study area. The area is covered by older alluvium and laterite. In Bolpur area the lithology changes abruptly from the rest of Birbhum district and important granular zone occurs between 250m to 450m below land surface having a cumulative thickness of around 100m to 110m. Ground water occurred under water-Table conditions in shallow aquifers and under confined conditions in the deep aquifer. Depth of water-Table varies 2 to 14m below land surface.

EXPERIMENTAL

Materials and Methods

Groundwater samples were collected from the 32 shallow tubewells (avg 45meters depth), 30 deep tubewells (80m avg), 12 supply water (from borewells) and 15 dugwells following the standard guidelines[6,9]during Pre-monsoon (April), monsoon(July) and post monsoon (November) season, 2013and were analyzed for various chemical parameters as described by APHA 1995. The location data were recorded using GPS. The parameters include Temperature, pH, EC, Total hardness, TDS, cations like Ca^{2+}, Na^+, K^+, Fe^{2+}, Mg^{2+} and anions like HCO_3^-, CO_3^{2-}, NO_3^-, PO_4^{3-}, SO_4^{2-}. Temperature, pH was measured in field pH meter and Orion ion selective electrode. EC, fluoride, nitrate was measured in Orion ion selective electrode (Model Meter 1119000). Ca^{2+}, Na^+, K^+ was measured using Elico Flame Photometer. HCO_3^-, $CO_3^{2-}$was measured using titrimetric method. Phosphate was measured by stannous chloride method (spectrophotometric method) and sulphate by turbidimetric method (spectrophotometric method).

TDS was measured by TDS meter. Fe^{2+} measured by Phenanthroline method. Hardness and magnesium was estimated by standard methods recommended by APHA, 1995. SAR (Sodium adsorption ratio) and %Na of all water samples for every season was calculated using standard formula:[2,10,11]

$$SAR = Na^+/\{(Ca^{2+} + Mg^{2+}) \div 2\}^{1/2}$$

$$\%\ Na = (Na^+) \times 100/(Ca^{2+} + Mg^{2+} + Na^+ + k^+)$$

All the ionic concentrations are expressed in epm in calculation.

Correlation coefficients of the chemical parameters were analyzed statistically.

RESULTS AND DISCUSSION

The summary of obtained results of physico-chemical analysis of water samples are given in Table-1. In this table the minimum and maximum concentration of major ions of the groundwater samples along with statistical summary and official safe limits for drinking water are given. The classification of water samples on the basis of Total Hardness[12] is given in Table- 2 and the statistical correlation coefficient of major ions are described in Table- 3.

The temperature of the water Samples was in the range 30.5^o – 32.9° C during pre-monsoon season, 28^o-32 ^{0}C during monsoon and 23.4^{0}C – 25.6^{0}C in post-monsoon period. The pH value of groundwater of the

Vol. 9 | No. 4 |627 - 633 | October - December | 2016

study area ranges between 6.51 to 8 (mean7.2) indicates slightly alkaline type of groundwater. In all the seasons the pH value of the samples are well within the safe limit prescribed by WHO, 1984. During pre-monsoon season the EC ranges between 298- 1177 μS/cm (Table- 1) and EC was found to be elevated in 100% shallow tubewell samples, 93.34% dugwell samples, 100% supply water samples and 100% deep tubewell samples. During monsoon season EC ranged between 278- 1172μS/cm and was found to be elevated in 96.87% shallow tubewell, 93.34% dugwell, 100% supply water and 96.6 % deep tubewell samples. During post monsoon season EC ranged between 278- 1171 μS/cm (Table- 1) and found to be elevated in 96.875% shallow tubewell, 93.34% dugwell, 100% supply water and 96.67% deep-tubewell samples. The large variation in EC in the study area can be attributed to semiarid climate, hard rock with low groundwater table and the geochemical processes prevailing in this region.

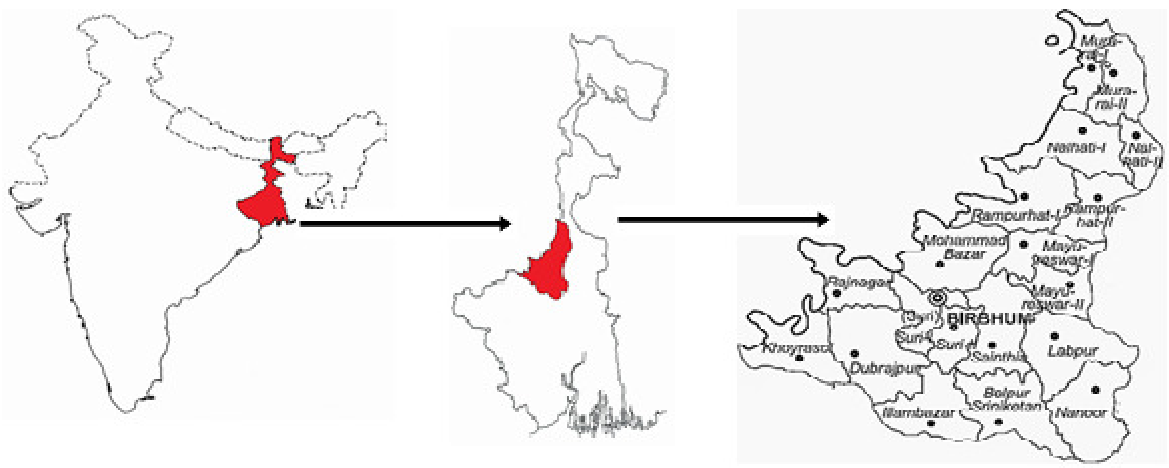

Fig.-1: Location Map of Study Area

Table-1: Range of physicochemical parameters with Statistical Summary at Different Seasons with officially accepted Limits

Ions	Pre-Monsoon Samples(mg/l)				Monsoon Samples(mg/l)				Post-Monsoon Samples(mg/l)				Max. Acceptable Limits (WHO)
	Min.	Max.	Mean	Std. dev	Min.	Max.	Mean	Std. dev	Min.	Max.	mean	Std. dev	
Na^+	0.91	29.01	11.74	6.03	0.8	27.9	9.73	5.112	1.19	26.3	9.71	5.43	200
K^+	0.04	62.3	21.54	17.84	0.06	61.4	19.89	15.23	0.04	58	18.911	15.12	20
Ca^{2+}	56.5	85.3	76.8	6.92	52.5	82	73.17	5.23	53	83.2	70.45	5.121	75
Mg^{2+}	2.00	4.10	2.89	0.63	2.00	3.5	2.54	0.54	2.00	4.00	2.51	0.521	50
CO_3^{2-}	0	0	0	0	0	0	0	0	0	0	0	0	350
HCO_3^-	159	223	186.16	18.32	152	223	183.3	18.50	151.4	219	181.25	17.56	384
SO_4^{2-}	0.41	48.98	8.67	9.75	0.35	43.63	6.45	7.911	0.38	48	7.645	9.023	400
NO_3^-	0.79	16.11	3.76	3.37	0.88	18.43	3.81	3.37	0.6	16.5	3.53	2.656	45
PO_4^{3-}	0.003	1.3	0.242	0.40	0.003	1.26	0.21	0.31	0.003	1.29	0.224	0.387	5
F^-	0.21	0.88	0.583	0.14	0.112	0.88	0.5	0.111	0.16	0.9	0.551	0.121	1.0
Fe^{2+}	0.12	1.77	0.786	0.35	0.12	1.39	0.671	0.245	0.2	1.77	0.68	0.281	0.3

EC	298	1177	595.7	526.24	278	1172	579	517	281	1171	571	513.3	300
TH	112	201.5	164.32	26.818	102	189	158.45	25.56	105	185	156.42	25.23	500
TDS	153	634	268.5	81.867	142	631	260.6	80.32	148	633	261	80.21	1000
pH	6.53	8			6.64	7.83			6.51	8			6.5- 8.5
TEMP.	30.5	32.9			28	32			23.4	25.6			

EC expressed in µS/cm, Temperature in ^{0}C. Rest of the parameters are expressed in mg/l.

The total hardness value was within the permissible limit in all samples for all the seasons. According to TH classification (Sawyer and Mc Carthy 1967), during Pre-monsoon season 21 samples fall under moderate hard, 68 samples were hard. During monsoon season 30 samples were moderate hard and 59 samples were hard. Among post monsoon samples 29 samples were moderate hard and 60 samples were hard (Table-2). No samples were found to be very hard.

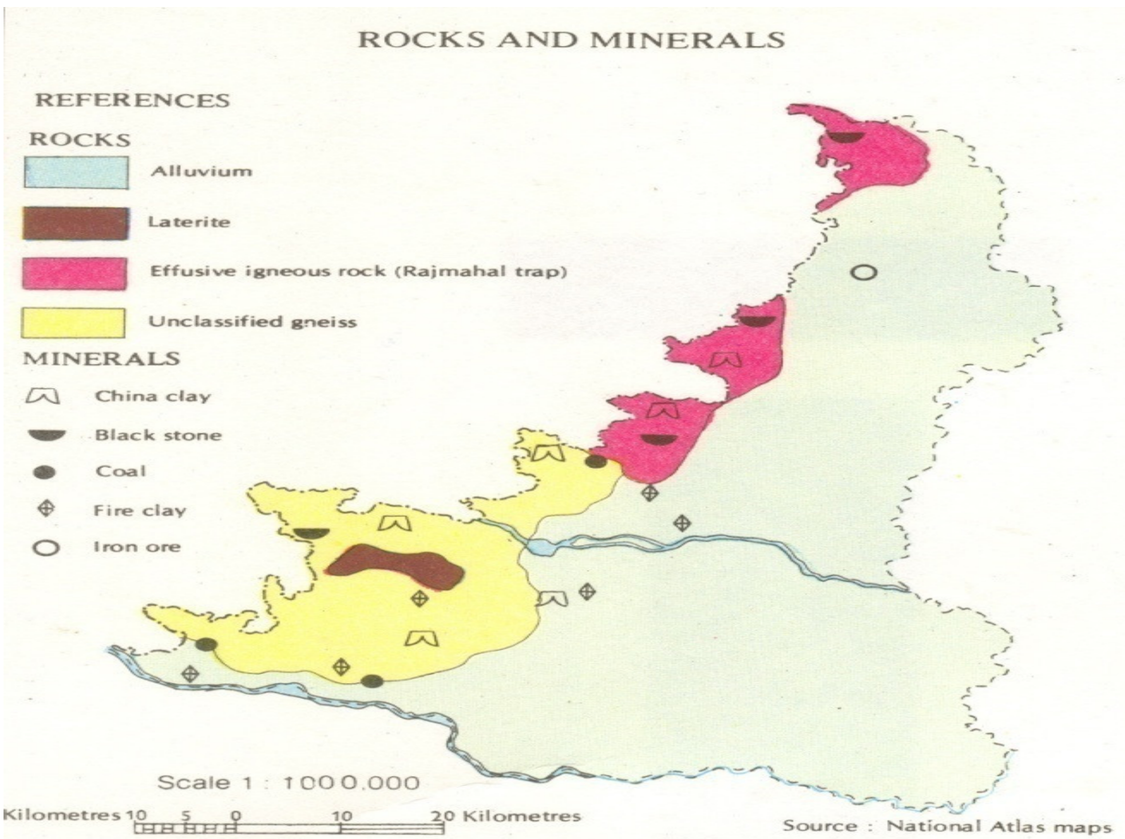

Fig.-2: Lithological map of the study area

Na^+ plays different role in human body. It is related to the function of nervous system, membrane system and excretory system. Excess sodium causes high blood pressure, nervous disorder etc. According to USEPA[13] the maximum permissible limit for sodium is 20mg/l, and according to WHO 1984, it is 200mg/l. In all the test samples Na^+ concentration was below 200mg/l in all seasons but in some samples it was above 20mg/l. During Pre-monsoon season Na^+ ranges between 0.91- 29.01 mg/l and was found to be elevated in 6.25% shallow tubewell samples, 0% dug-well samples, 8.34% supply-water and 30% deep-tubewell samples. Among monsoon samples Na^+ concentration ranged between 0.8- 27.9mg/land was found to be elevated in 3.125% shallow tube-well, 6.67% dug-well, 8.34% supply water and 16.67% deep-tubewell samples. Among post monsoon samples Na^+ concentration ranged between 1.19- 26.3 mg/l and was found to be elevated in 3.12% shallow tubewell, 0% dugwell, 8.34% supply water and 16.67% deep-tubewell samples.

Ca^{2+}concentration in the study area ranged between 56.5 to 85.3mg/l during pre-monsoon and was found to be elevated in 27 shallow tubewell samples among 32 samples (above 75mg/l),13dugwell samples, 7 supply water samples and in 17 deep-tubewell samples. Among monsoon samples Ca^{2+}concentration was found to be elevated in 12 shallow tubewells, 5 dug-wells, 2 supply-water and 13 deep-tubewell samples. The range of calcium concentration is given in Table- 1. Among post monsoon samples Ca^{2+} content was found to be elevated in 12 shallow-tubewells, 3 dug-wells, 4 supply water and 7 deep-tubewell samples. Elevated concentration of Na^+ and Ca^{2+} in ground water is attributed to cation exchange among minerals. K^+ concentration among the test samples ranges between 0.04 to 62.3mg/l during pre-monsoon and was found to be elevated in 34.37% shallow tubewell samples, 50% dugwell, 66.67% supply water and 40% deep-tubewell samples (above 20mg/l). Among monsoon samples K^+ concentration ranged between 0.06 -61.4mg/l and was found to be elevated in 31.25% shallow tubewell, 66.67% dugwell, 66.67% supply water and 36.67% deep-tubewell samples. In post monsoon K^+ concentration ranged between 0.04 – 58mg/l and was found to be elevated in 25% shallow tubewell, 66.67% dugwell, 66.66% supply water and 36.67% deep tubewell samples. Minerals like Orthocase, biotite and microcline may be source of K^+ in groundwater.

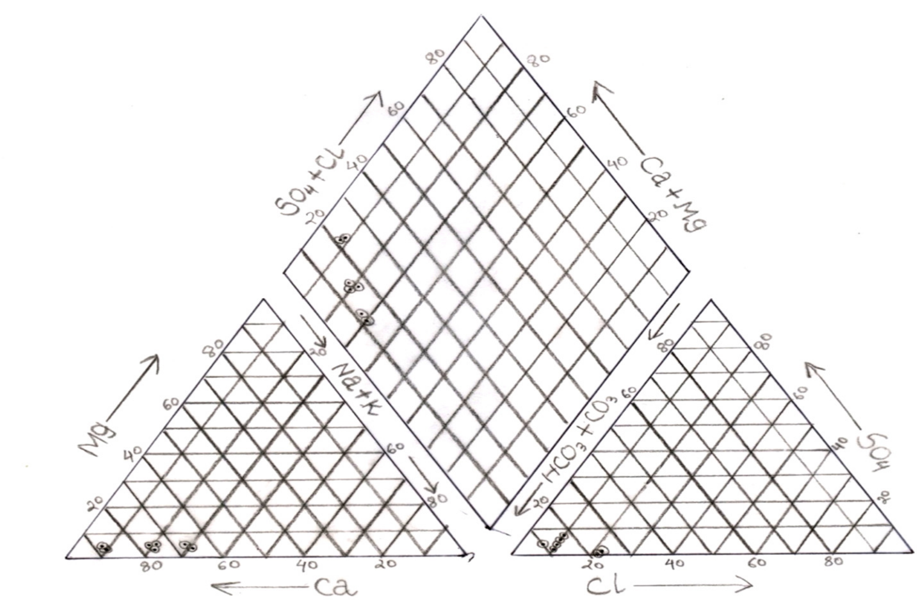

Fig.-3: Piper diagram showing the hydrogeochemical facies of Bolpur block, shows all samples are SO_4+ Cl type.

Maximum samples in the study area was found to be iron contaminated. In pre-monsoon samples it was found to range between 0.12 – 1.77 mg/l. Among monsoon samples the range of Fe^{2+} was 0.12 – 1.39mg/l and among post monsoon samples the range was 0.2 – 1.77mg/l. Among the pre-monsoon samples 100% contained Fe^{2+} above 0.3 mg/l and 43.75% samples above 1mg/l. Among the dug-well samples none was above 1mg/l, but 40% samples showed above 0.3mg/l Fe^{2+}. In all supply water samples Fe^{2+} content was above 0.3mg/l and 58.34% samples were found to have above 1mg/l Fe^+. Out of 30 deep tubewell samples, 29contains above 0.3mg/l and 40% samples contains more than 1mg/l Fe^{2+}. The acceptable limit of Fe^+ is 0.3mg/l and maximum permissible limit is 1mg/l(WHO 1984).In monsoon Fe^{2+}concentration was above 0.3mg/l in 100% shallow tubewell, 40% dug-well samples, 100% supply water and 96.66% deep-tubewell samples. Fe^{2+} above 1mg/l was observed in 43.75% shallow tubewell, 0% dug-well, 58.3% supply-water and 40% deep-tubewell samples. During post monsoon season Fe^{2+}concentration was above 0.3mg/l in 100% shallow tubewell samples, 40% dug-well samples, 100% supply water and 96.67% deep-tubewell samples. Above 1mg/l was observed in 40.625% shallow tubewell, 0% dug-well, 58.34% supply-water and 43.34% deep-tubewell samples.

Elevated nitrate is known to cause serious health problems including methemoglobinemia and potential carcinogenic effects. According to WHO (1984) the permissible limit of NO_3^- is 45mg/l but according to USEPA the permissible limit for NO_3^- is 10mg/l. The range of NO_3^- concentration during pre-monsoon was 0.79 – 16.11mg/l and was found to be elevated in 3.12% shallow tubewell, 20% dug-well, 0% supply water and 10% deep-tubewell samples show elevated NO_3^- concentration. Among monsoon samples NO_3^- concentration ranged between 0.88 – 18.43mg/l and was found to be elevated in 9.37% shallow tubewell, 20% dugwell, 0% supply water and 10% deep-tubewell samples. In the post-monsoon samples NO_3^- concentration ranged between 0.6 – 16.5mg/l and was found to be elevated in 3.13% shallow tubewell, 20% dugwell, 0% supply water and 10% deep-tubewell samples. Elevated NO_3^- concentration in groundwater may be due to excessive use of chemical fertilizers in the agricultural fields.

Mg^{2+} concentration in all samples ranges within permissible limit 50mg/l in all the seasons. The SO_4^{2-} ,$HCO_3^-$and PO_4^{3-}concentrations were within the permissible limit in all seasons. As per WHO guidelines the TDS concentrations are all within permissible limit (1000mg/l) for all seasons in all samples but according to USEPA the maximum desirable limit is 500mg/l. Thus according to USEPA elevations in TDS is present. TDS is directly related to electrical conductivity of water sample. Carbonate could not be traced in any sample of this area.

In all samples throughout the year the fluoride concentration was within permissible limit (1.5mg/l). Maximum F^- concentration was found to be 0.9mg/l. Birbhum is one of the worstly fluoride affected district in West Bengal but in this study area none of the samples shows elevated fluoride concentration.

Table-3 shows that in Bolpur block fluoride is negatively correlated to pH and Ca^{2+} and positively correlated to Na^+, K^+ and SO_4^{2-}. Na^+, K^+, Ca^{2+} and Mg^{2+} shows significant positive correlations with each other.

Table- 2: Classification of Water based on Hardness by Sawyer & Mc Carthy

Hardness as $CaCO_3$(ppm)	Water Class	Pre-monsoon Samples	Monsoon	Post-monsoon Samples
0-75	Soft	0samples	0 samples	0 samples
75-150	Moderate hard	21 samples (112-150mg/l)	30 samples (102- 150)	29 samples (105-150mg/l)
150-300	Hard	68 samples (151-201.5mg/l)	59 samples (151-189mg/l)	60 samples (151- 185)
>300	Very hard	0 samples	0 samples	0 samples

Among all the pre-monsoon samples maximum SAR (Sodium Adsorption Ratio) was found to be 0.9643 (shallow tubewell sample). Among monsoon samples maximum Sodium Adsorption Ratio was found to be 0.938 (deep tubewell sample) and among post-monsoon samples maximum Sodium Adsorption Ratio was found to be 0.951(deep tubewell sample). According to Hem (1989), the maximum permissible limit SAR for irrigation water is 10, thus all the test samples are within safe limits in all seasons.

%Na was found to be maximum 20 (in Pre-monsoon season). Among the monsoon samples maximum %Na was found to be 19.3 and among the post monsoon samples maximum %Na was found to be 19.43 which indicates that %Na in all samples are within the safe limit as %Na 20 is the safe limit for irrigation water.[2]

As in all the samples the bicarbonate concentration was within permissible limit 384mg/l (WHO, 1984) thus the Residual Sodium Carbonate (RSC) was not calculated as it is the index to determine the HCO_3^- hazard [14]. Ground water with a base exchange reaction in which the alkaline earths have been exchanged for Na^+ ions ($HCO_3^- > Ca^{2+} + Mg^{2+}$) may be referred to as base-exchanged-softened water, and those in which the Na^+ ions have been exchanged for the alkaline earths ($Ca^{2+} + Mg^{2+} > HCO_3^-$) may be referred to as base-exchanged-hardened water[15]. In the study area in all the samples Ca^{2+} + Mg^{2+}> HCO_3^- that means base-exchanged-hardened water. Figure-3 shows in Bolpur block all samples areSO_4+ Cl type.

Table-3: Correlation Coefficient of the Chemical Parameters of Ground Water Samples (Bolpur Block)

	pH	EC	TDS	F^-	TH	NO_3^-	SO_4^-	PO_4^-	Ca^+	Na^+	K^+	Fe^+	Mg^+	HCO_3^-
pH	1	-0.175	-0.0468	-0.1486	0.227	-0.169	-0.126	0.125	0.035	0.0158	-0.049	0.3	-0.322	0.052
EC		1	0.297	-0.0087	0.138	0.089	0.102	-0.042	0.068	0.062	-0.0212	-0.0575	0.169	0.103
TDS			1	0.1189	-0.046	0.35	0.345	-0.1005	0.063	0.0632	0.213	-0.03	-0.093	-0.233
F^-				1	-0.088	0.259	0.171	0.067	0.114	-0.222	-0.221	0.087	-0.043	-0.086
TH					1	-0.053	0.058	-0.002	0.186	-0.015	-0.091	0.166	-0.103	-0.014
NO_3^-						1	0.474	-0.035	-0.052	-0.105	0.184	-0.098	0.344	0.114
SO_4^-							1	0.028	-0.056	-0.035	0.082	-0.261	0.081	-0.186
PO_4^-								1	-0.191	0.01	-0.061	0.2072	0.003	0.035
Ca^+									1	-0.527	-0.2585	-0.087	0.048	-0.109
Na^+										1	0.2569	-0.016	-0.231	0.047
K^+											1	-0.155	0.066	0.0765
Fe^+												1	-0.038	0.086
Mg^+													1	0.241
HCO_3^-														1

CONCLUSION

From the obtained results we found that some of the groundwater samples in Bolpur block are unsuitable for drinking as few parameters are elevated but for irrigation it is safe and suitable.

REFERENCES

1. C.A. Appelo, D. Postma, Geochemistry, Groundwater and Pollution, Balkema, Rotterdam.(1993)
2. L.V. Wilcox, *Agric.Bull*., **40**, 1962 (1948)
3. D.W. Thorne, H.B. Peterson, Irrigated soils, Constable- and Company, London, (1954)
4. D.K. Todd, Groundwater Hydrology, Wiley, New York, 2nd edn. (1980)
5. WHO Guidelines for Drinking Water Quality, Vol. **l** Recommendations, World Health Organization, Geneva. (1984).
6. J.D. Hem, Study and interpretation of the chemical characteristics of natural waters,3rd edition. Scientific publishers, Jodhpur,(1991)
7. K.R. Karanth, Groundwater assessment, development and management, Tata McGraw-Hill, New Delhi(1997)
8. A. Zaporozee, *Groundwater,***10**, 32(1972)
9. APHA, Standard method for examination of water and wastewater, American Public Health Association, 19th edition. Washington, *DC*, (1995)
10. J.D. Hem, Study and interpretation of the chemical characteristics of natural waters, 3rd edition. US geological survey water supply paper, **2254**(1989)
11. L.A. Richards, Diagnosis and improvement of saline and alkali soil, US Department of Agriculture, Agriculture Handbook,60 (1954)
12. C.N. Sawyer, P.L. McCarthy, Chemistry of sanitary Engineers, 2nd edition. McGraw Hill, New York, 518(1967)
13. USEPA, The water quality standards handbook, United states Environmental Protection Agency(1983)
14. W. McLean, J. Jankowski, N. Lavitt, Proceedings of the XXX IAH congress on groundwater: past achievements and future challenges. A.A., Balkema, Rotterdam, 567-573(2000)
15. B.K. Handa Groundwater pollution in India. In: Proceedings of national symposium on hydrology. *BHS,* Publ. Univ. Roorkee, India, 34- 49 (1979)

[RJC-1496/2016]