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Groundwater Hydrochemical Characterization of North-Eastern part of Bankura District, West Bengal, India.

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ABSTRACT

Deterioration of ground water quality due to geological and human activities is now a days a global issue. An assessment on the water quality parameters from north- eastern part of Bankura District, West Bengal (India) was carried out during the period of pre and post monsoon of 2009-2010. The investigation involved the sampling of 23 ground water samples from 23 different locations. Water table contour map as prepared by collected water level data suggests the presence of ground water trough consisting of radial flow. There is no change in flow regime during pre and post-monsoon. The samples were analyzed for different physico-chemical variables like pH, TDS, EC, Alkalinity, TH, Ca, Mg, NO_3, SO_4, Na, Cl and K. Marked seasonal variation of some physico-chemical parameters such as pH, TDS, Alkalinity has been observed. pH of most of the samples in pre- monsoon are alkaline in nature (6.8-8.28). An overall higher concentration of TDS in pre-monsoon in comparison to post-monsoon suggests dilution of aquifer. The maximum difference in TDS concentration between pre and post- monsoon in a particular location is 3310 ppm. Most of the samples in pre-monsoon (443ppm-6040 ppm) cross the permissible limit for TDS (500-2000mg/l) in potable water. Alkalinity increases from pre-monsoon (45.28ppm-222.62ppm) to post-monsoon (55.494-1336.62ppm) season. SO_4 and Cl show significant seasonal variation in concentration. Most of the samples show less concentration of Ca and Mg in pre- monsoon. The correlation coefficient between Ca & Cl (0.937), Mg & Cl (0.895), SO_4 & Cl (0.849), SO_4 & Mg (0.727), SO_4 & Ca (0.704) reveal significant correlation between these parameters and provide input to infer the aquifer- ground water interaction.

Keywords: Groundwater, water quality, water table contour map, correlation coefficient, Bankura District

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INTRODUCTION

Ground water is an essential and vital natural resource of our life support system. Ground water resources are being utilized excessively for drinking, irrigation and industrial purposes. Demand for drinking clean water increases continually with increase in population growth of the world. People in many areas of the world lack the fresh drinkable water essential to their survival. Maintaining secure water supplies for drinking, industry and agriculture would be impossible without groundwater, the largest and most reliable of all fresh-water resources. Groundwater forms the major source of water supply for drinking purposes in most parts of India. It accounts for about 88% safe drinking water in rural areas, where the population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Groundwater also plays an important role in agriculture. It is estimated that about 45% of irrigation water requirement is met from groundwater sources. With rapid increase in population and growth of industrialization, groundwater quality is being increasingly threatened by agricultural chemicals and disposal of urban and industrial wastes.

The present study involves the assessment on the water quality parameters from north-eastern part of Bankura district, West Bengal which was carried out during the period of 2009-2010. The district is located between latitude 22°38´N and longitude 86°36´E to 87°47´E. The Damodar River flows along the northern boundary of the district. The investigation involved the sampling of 23 groundwater samples from 23 different locations (Table 1). The samples were analyzed for different physico-chemical variables like pH, TDS, EC, Alkalinity, TH, Ca, Mg, NO_3, SO_4, Na, Cl, and K.

Table 1: Location

Loation no.	Location name	Longitude	Latitude
1	Kadasol	87°1632 E	23°2619 N
2	Kadasol	87°1634 E	23°2624 N
3	Ghutgoria	87°1543 E	23°2637 N
4	Keshabpur	87°1424 E	23°2749 N
5	Keshabpur	87°1428 E	23°2748 N
6	Tentulpoa	87°1452 E	23°2756 N
7	Chandannagar	87°830 E	23°3032 N
8	Manohar	87°1354 E	23°2744 N
9	Chakuldanga	87°1220 E	23°2714 N
10	Anandapur	87°1247 E	23°2622 N
11	Tarkabad	87°1200 E	23°2635 N
12	Bankdoha	87°107 E	23°2552 N
13	Nityanandapur	87°1132 E	23°2729 N
14	Nityanandapur	87°1133 E	23°2730 N
15	Uparsol	87°1544 E	23°2823 N
16	Uparsol	87°1542 E	23°2823 N
17	Maliara	87°1346 E	23°2832 N
18	Jalanpur	87°1436 E	23°3012 N
19	Srirampur Barsal	87°112 E	23°2949 N
20	Sahebdanga	87°1635 E	23°2719 N
21	Jamaddargram	87°186 E	23°2634 N
22	Sitarampur	87°1835 E	23°2846 N
23	Sitarampur	87°1834 E	23°2845 N

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Study area

The area under investigation belongs to the survey of India toposheet (1: 50,000 scale) NO. 73 M/2 and 73M/7 lying between latitude 23º30´N and longitude 87º10´E to 87º20´E, total area coverage is almost 180 km^2 (Figure1). The climate, especially in the eastern part is much drier than in western or southern part of the district. The seasons in Bankura are generally distributed as hot summer (April-May), monsoon (June-September) and cold season (November-February). The humidity is usually medium to high throughout the year and the rainfall, is usually well distributed. The average annual rainfall received by the district is around 1300mm. The rainy months are generally July and August [1].

Geology

The study area is characterized broadly by four lithounits as under:

- Crystalline granite gneiss of Archaean age is expressed in the western part of the study area.
- Sedimentary sandstone and shale of lower Gondwana age occupy the northern and north western parts of the study area as small patches, covering parts of Saltora and Mejia blocks, which is the southern extension of Raniganj Coalfield.
- Quaternary alluvium occupies the eastern and south-eastern parts of the district.
- The marginal tract including parts of Barjora also covered by laterites and quaternary alluvium underlain by basement rock at shallow depth within 40 m [2,3].

The greater portion of the study area consists of a rolling country covered by laterite and alluvium.To the east there is a wide plain of recent alluvium. The most characteristic geological feature of the study area is the area of laterite and associated rocks of sand and gravel. The Gondwana supergroup is represented in the northern portion of the district, south of Damodar, between Mejia and Biharinath Hill. The beds covered with alluvium contains seams of coal belonging to the Raniganj Formation [1].

Figure 1

Hydrogeology

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Groundwater in the study area occurs both under water-table condition and confined condition. In the consolidated/semiconsolidated/hard crystalline rocks, groundwater occurs in:

- Weathered residuum within 10 mbgl.
- Fractures within 65 mbgl having discharge within 20 m^3/hr.

In the unconsolidated/recent alluvium, groundwater occurs both under unconfined and confined condition within the explored depth of maximum 600 mbgl. Aquifers are fairly thick and regionally extensive with large yield prospect of about 150 m^3/hr. In this district aquifers beyond 136 mbgl upto the drilled depth of 350 mbgl in the Tertiary formation are found under autoflow condition [2,4].

MATERIALS AND METHODS

Groundwater samples were collected in 2.5 litre polyethylene container in the field. Electrical conductivity and pH of the samples were measured within 4 hours of sample collection. The samples were analyzed for parameters like total hardness, alkalinity, nitrate, chloride, sodium, potassium, calcium, sulfate, etc. Analyses of samples have been done following the standard methods adopted by APHA [5]. The pH and EC were measured by means of pH meter (EUTECH pH 1100) and conductivity meter (EUTECH con. 510) respectively. The TDS of the samples were also computed from conductivity meter. Na^+ and K^+ were determined by flame photometer (TECHCOMP UV-2300). NO3, SO_4 were analyzed spectrophotometrically. TH, TA, Cl were analyzed by titrimetric method.

RESULTS AND DISCUSSIONS

Fluctuation of water table

Depth to water level data were collected from 23 wells located at different parts of the study area in pre-monsoon and post monsoon season. Figure 2 and Figure 3 represent the water table contour maps of pre-monsoon and post monsoon respectively. Groundwater level data collected from the study area show that water table depth lies in between 60.23m- 104.71m during pre-monsoon and 60.36m-106.95m during post monsoon. Northern part of the study area includes villages like Chandannagar, Srirampur Barsal and Jalanpur, central part includes villages like Manohar, Keshabpur, Tentulpoa, eastern part includes villages like Sitarampur, Uparsol, Sahebdanga, the western part includes villages like Nityanandapur, Chakuldanga and the southern part includes villages like Kadasol, Ghutgoria and Tarkabad. Difference between water level data collected in postmonsoon season and in premonsoon season indicates total fluctuation of ground water. In the northern part, the total fluctuations ranges from 3.4m to 6.94m, in the central part 3.64m to 6.66m, in the eastern part 2.59m to 3.78m, in the western part 5.07m to 5.67m and in the southern part 2.02m to 8.83m (Figure 4). Contour maps of groundwater table are prepared from water levels in wells. There is no as such change in flow pattern during pre and post monsoon. In the northern part, the groundwater flow direction is towards southwards and in the southern part flow direction is towards northwards. In the central part there is a presence of groundwater trough consisting of radial flow. Contour of groundwater table shows that the gradient is gentler in the western part in comparison to the east (Figure2) and gradient is gentler

in the central part than the northern side. Due to the gentler slope of water table in the western part, the permeability of the aquifer will be more. The contact time between the groundwater and the aquifer will be more, resulting in more mineral concentration.

Results from Groundwater Sample Analysis

Groundwater quality data gives important clues to the geologic history of rocks [6]. The physico-chemical analysis was performed following standard methods of APHA (APHA 1995). The pH values in the groundwater of the study area are mostly confined within the range 6.8 to 8.2 during the pre-monsoon season and 6.2 to 7.4 during the post-monsoon season. The pH values increases in pre-monsoon than post-monsoon (Figure 5). The EC values of the samples vary from 140 µs to 3020 µs in pre-monsoon and 329 µs to 5460µs in post-monsoon. In natural water, dissolved solids consists mainly of inorganic salts such as

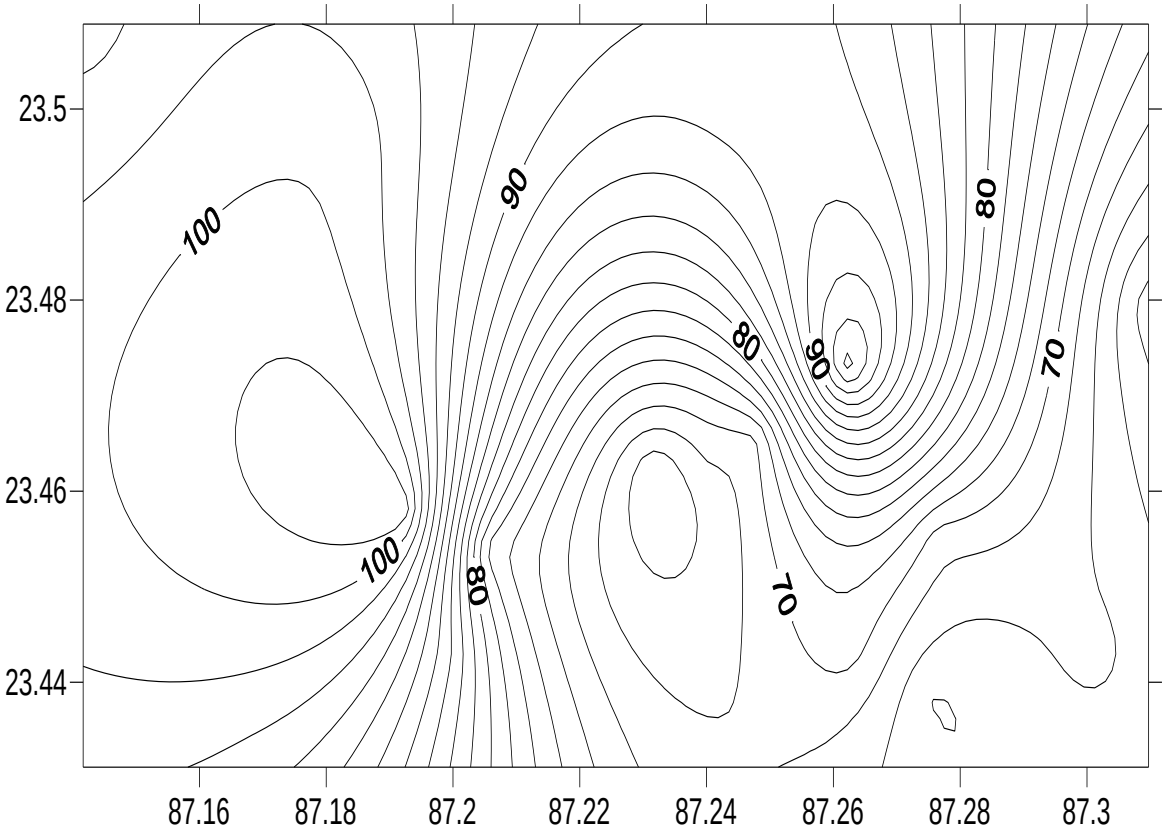

Figure 2: Pre-monsoon contour map

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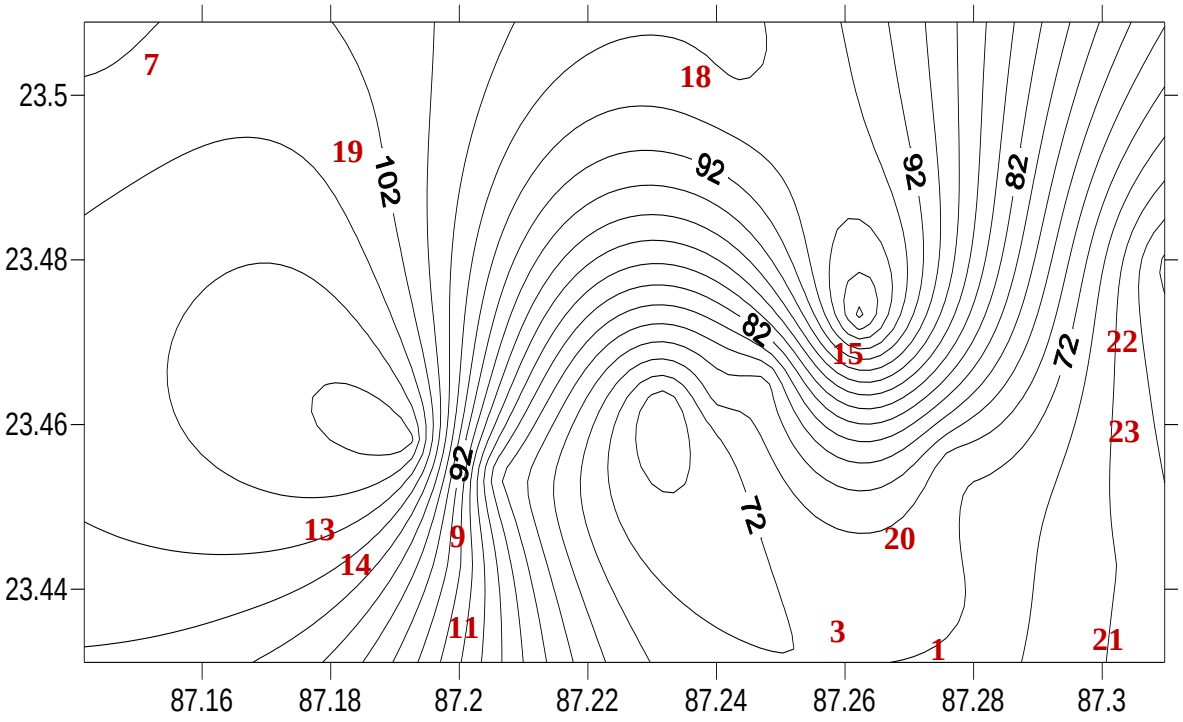

Figure 3: Post monsoon contour map

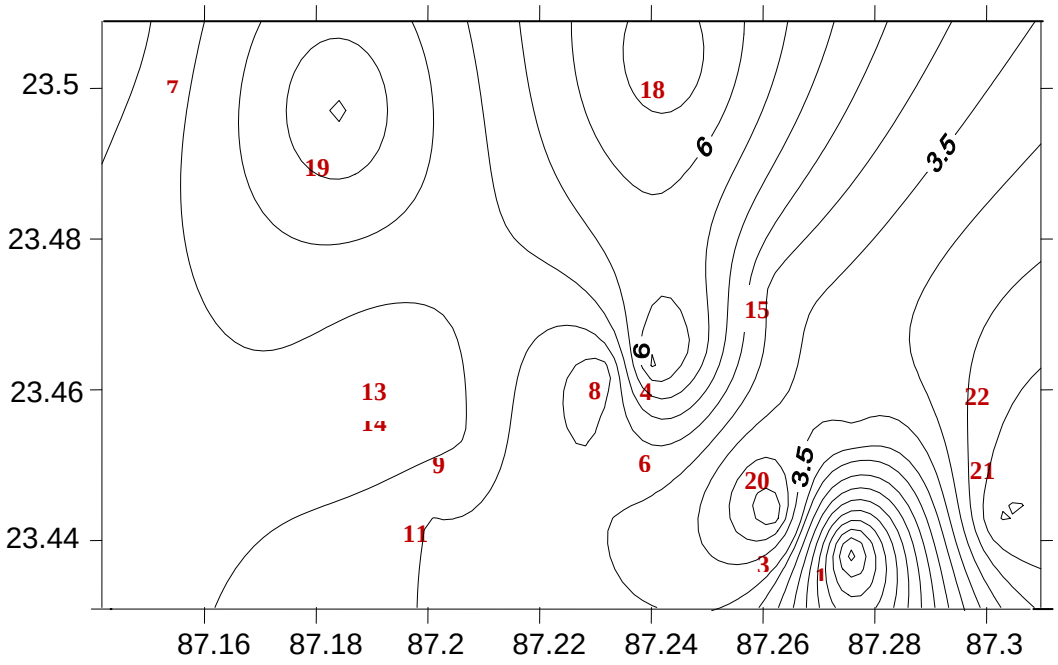

Figure 4: Contour map showing fluctuation

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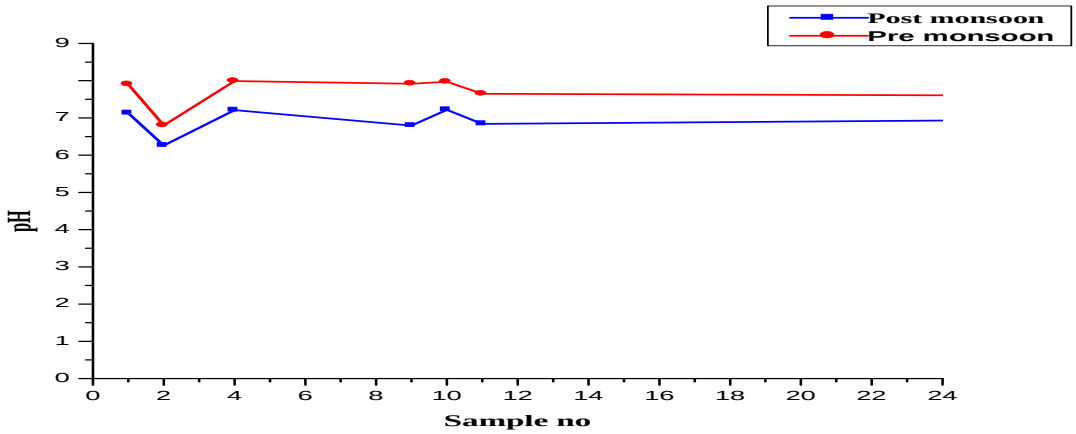

Figure 5: Variation of pH with respect to pre and post monsoon

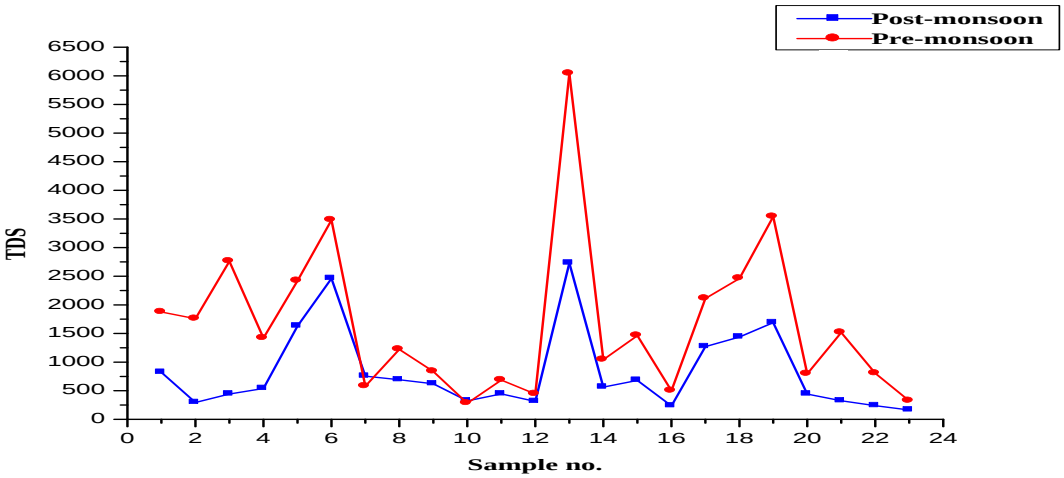

Figure 6: Variation of TDS with respect to pre and post-monsoon

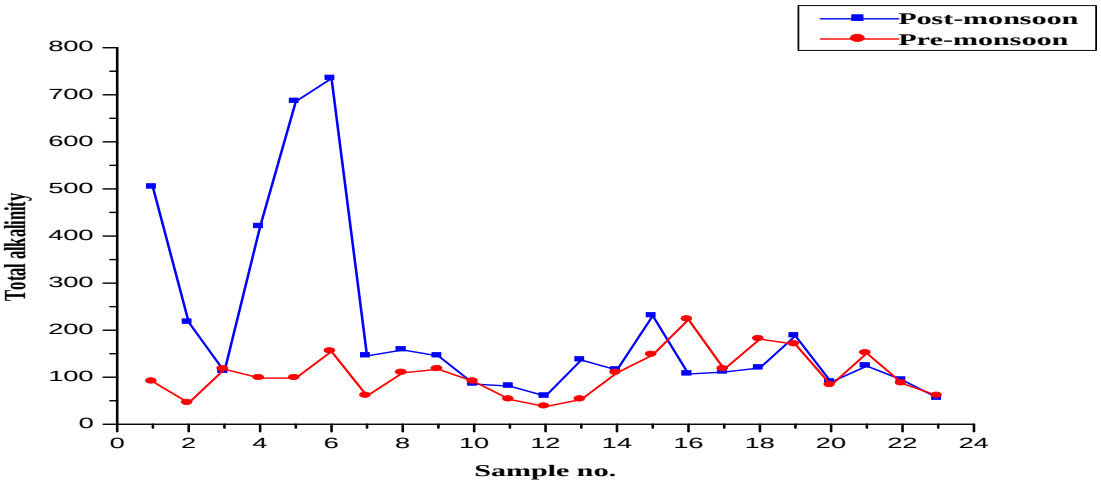

Figure 7: Variation of TA with respect to pre and post-monsoon

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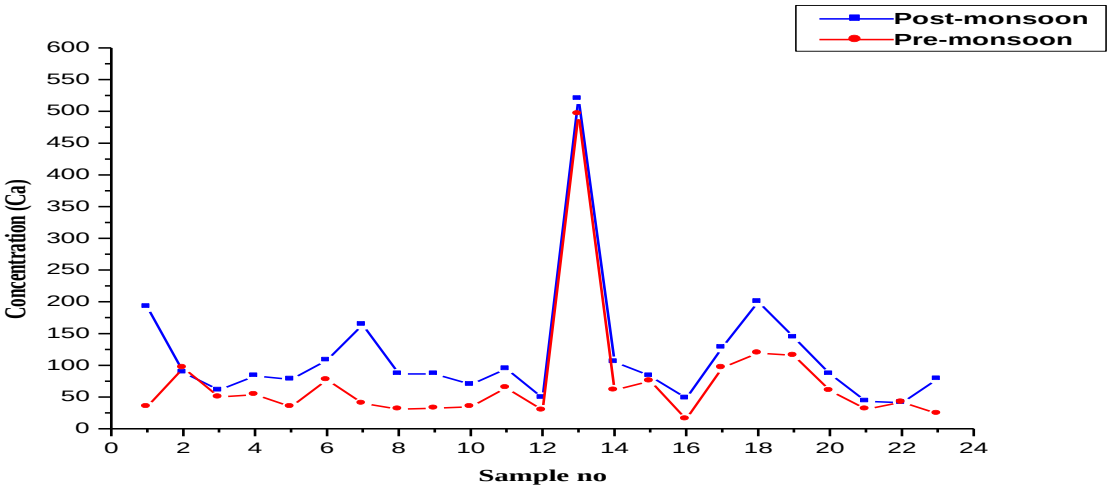

Figure 8: Variation of Ca conc. with respect to pre and post-monsoon

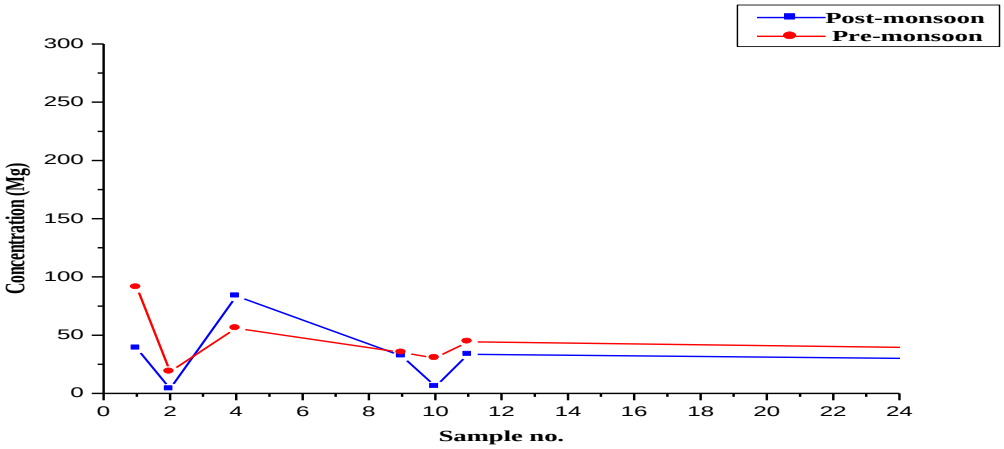

Figure 9: Variation of Mg conc. with respect to pre and post-monsoon

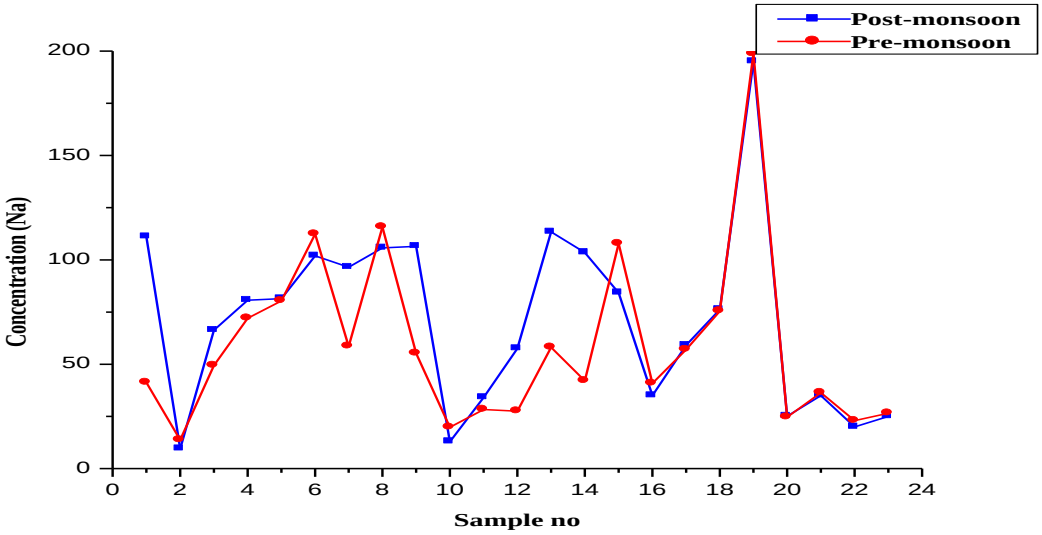

Figure 10. Variation of Na conc. with respect to pre and post-monsoon

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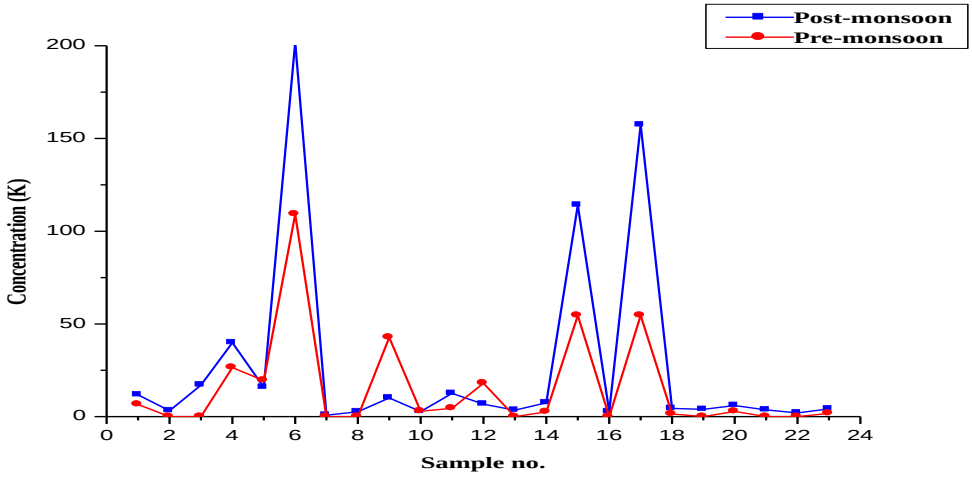

Figure 11: Variation of K conc. with respect to pre and post-monsoon

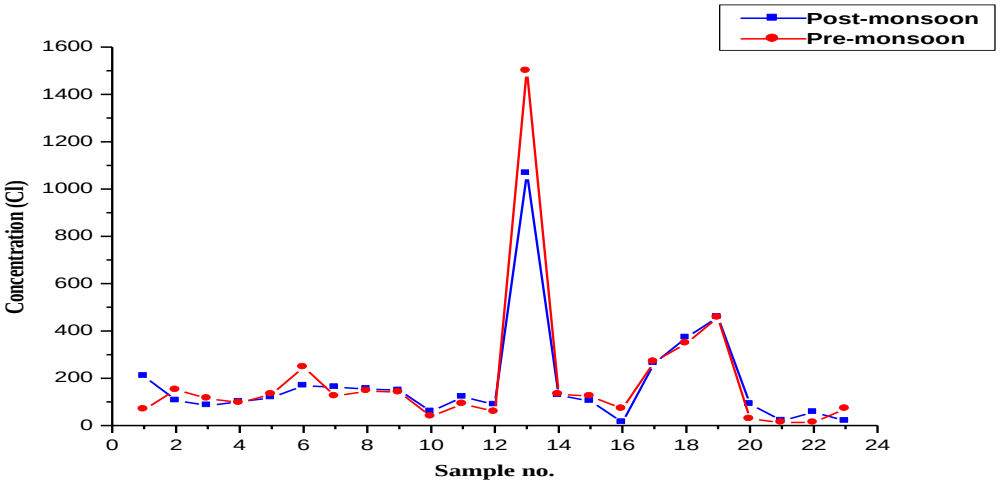

Figure 12: Variation of Cl conc. with respect to pre and post-monsoon

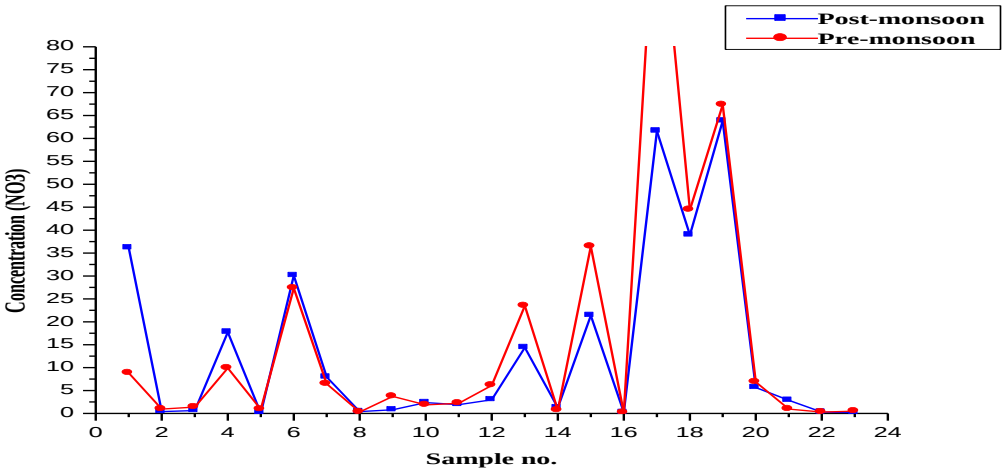

Figure 13: Variation of NO_3 conc. with respect to pre and post-monsoon

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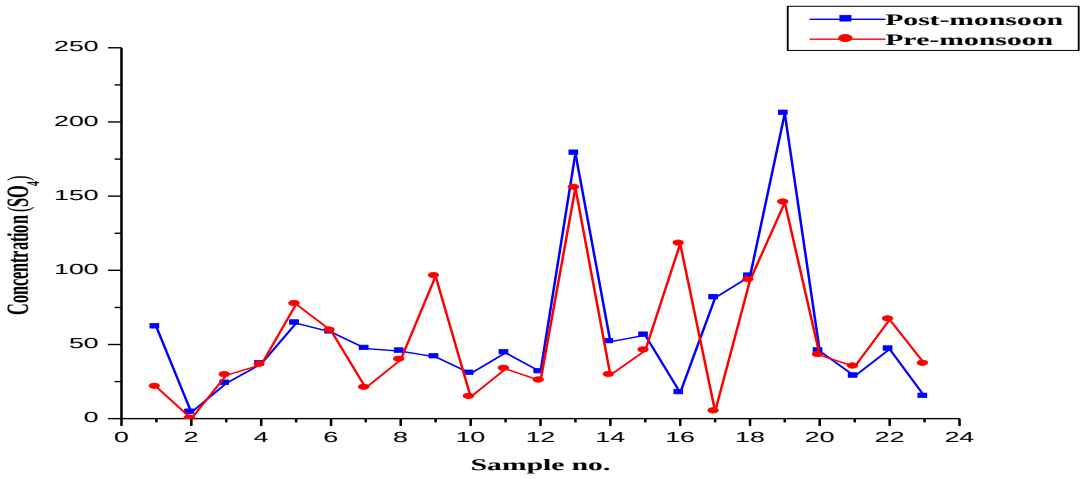

Figure 14: Variation of SO_4 conc. with respect to pre and post monsoon

Carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, Ca, Mg, Na, K etc. In the present study, the values of total dissolved solids (TDS) in the groundwater vary from 281ppm to 6040 ppm during the pre-monsoon and 164 ppm to 2730 ppm during the post monsoon. An overall higher concentration of TDS in pre-monsoon in comparison to post monsoon suggests dilution of aquifer (Figure 6). Most of the samples in pre-monsoon cross the permissible limit for TDS (500-2000mg/l). The TDS of the western part is more as compared to the central part. The alkalinity values varies from 45.28-222.62 during the pre-monsoon and from 55.494-1336.62 during the post-monsoon season. Almost all the samples of the study area fall within the desirable limit of 200 mg/l for alkalinity during the pre-monsoon season. During the post-monsoon season, few samples cross the desirable limit of 200 mg/l but are well within the maximum permissible limit of 600mg/l. Only 3 samples from the villages Chandannagar, Keshabpur, Manohar crosses the maximum permissible limit of 600mg/l for alkalinity during the post monsoon season (Figure 7). The desirable limit for Ca & Mg for drinking water is 75 & 30 mg/l respectively (BIS1991). The values of Ca range from 15.38-495.88 mg/l during the pre-monsoon and from 40.8-520 mg/l during the post-monsoon season. Most of the samples cross the desirable limit during the post-monsoon season (Figure 8). The western part samples show high concentration of Ca and Mg (Figure 8, 9). The concentration of Na & K reflects that both show increase in concentration during the post monsoon season (Figure 10, 11). The chloride content of the study area varies from 12.8-1499.96 during the pre-monsoon and from 13.6 – 1066.36 mg/l during the post monsoon season (Figure 12). Most of the samples fall within the desirable limit for Cl (250mg/l) except the samples of the villages like Nityanandapur, Srirampur, and Jalanpur, which crosses the desirable limit for Cl. The Nitrate content of the samples varies from 0.15-119.64 during the pre-monsoon and from 0.19-63.81 during the post monsoon (Figure 13). The nitrate content of almost all the samples are within the desirable limit for NO_3 (45mg/l) [7], [8] except two samples from the northern part, which crosses the desirable limit. The sulfate content in all the groundwater samples of the study area falls within the desirable limit of 200 mg/l (Figure 14). The correlation co-efficient of the parameters during pre-monsoon are: Ca & Cl (0.977), Mg & Cl (0.924), SO_4 & Cl (0.634), SO_4 & Mg (0.566) and SO_4 & Ca (0.538), SO_4 & TH (0.564) (Table 2). This result shows that correlation coefficient value of Ca & Cl, Mg & Cl in pre-monsoon are little higher than the values of post monsoon. SO_4 & Cl (0.849), SO_4 & Mg (0.727)

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and SO_4 & Ca (0.704), SO_4 & TH (0.754) in post monsoon show better correlation than pre-monsoon (Table 2, Table 3).

Table 2. Pearson Correlation Co- efficient (Pre-monsoon)

	pH	EC	TDS	Na	K	NO_3	SO_4	TH	Ca	Mg
pH	1									
EC	0.014	1								
TDS	0.012	1.000 **	1							
Na	0.06	-0.233	-0.233	1						
K	0.301	-0.14	-0.141	o.309	1					
NO_3	-0.14	-0.371	-0.371	0.464*	0.392	1				
SO_4	-0.21	-0.427	-0.427	0.484*	-0.062	0.132	1			
TH	-0.209	-0.25	-0.25	0.166	-0.073	0.211	0.564**	1		
Ca	-0.288	-0.282	-0.282	0.13	-0.052	0.261	0.538**	**0.980*** **	1	
Mg	-0.114	-0.203	-0.203	0.198	-0.093	0.145	0.566**	**0.976*** **	**0.913*** **	1
Cl	-0.238	-0.374	-0.375	0.262	-0.024	0.303	0.634**	**0.973*** **	**0.977*** **	**0.924*** **

Correlation is significant at the 0.01 level (2-tailed)
Correlation is significant at the 0.05 level (2-tailed)

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Table 3. Pearson Correlation Co-efficient (Post-monsoon)

	pH	EC	TDS	Na	K	NO3	SO4	TH	Ca	Mg	Cl
pH	1										
EC	0.27	1									
Na	0.245	0.043	0.043	1							
K	0.052	-0.185	-0.185	0.126	1						
NO3	0.128	-0.345	-0.344	0.57	0.463	1					
SO4	0.177	-0.414	-0.413	**0.737****	0.046	0.677	1				
TH	-0.03	-0.286	-0.286	0.483	-0.073	0.352	**0.754****	1			
Ca	-0.033	-0.19	-0.19	0.442	-0.03	0.316	**0.704****	0.957**	1		
Mg	-0.024	-0.371	-0.37	0.478	-0.116	0.354	**0.727****	0.935**	**0.792****	1	
Cl	Cl -0.019	-0.374	-0.374	0.546	-0.017	0.446	**0.849****	**0.969****	**0.937****	**0.895****	1

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CONCLUSION

From the above discussion it can be concluded that

i) Regional flow of groundwater is towards south. Local groundwater flow systems have also been developed in the study area.
ii) In the western part of the study area, the permeability of the aquifer is more.
iii) Aquifer-groundwater interaction is more in the western part as is evidenced by the concentration of TDS, Ca, Mg and Cl in western part of the study area.
iv) There is no change of flow pattern during pre and post monsoon.
v) Few samples cross the desirable limit for alkalinity and Cl respectively. Most of the samples cross the desirable limit for Ca.
vi) From correlation coefficient value it has been found that Ca^{2+} & Mg^{2+} are present as dominating cations and Cl^{-} is present as dominating anion.

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