International Journal of Advanced Geosciences, 9 (1) (2021) 1-4

International Journal of Advanced Geosciences

Website: www.sciencepubco.com/index.php/IJAG

Review

The factor analysis of groundwater quality data of the Tista floodplain and the Dharla floodplain, Kurigram, Bangladesh: Siderite dissolution is a source of iron in groundwater

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Abstract

The present research work deals with the hydrochemical nature of the groundwater samples of the Dharla and the Tista River floodplains of Kurigram district, Bangladesh. The mechanism of groundwater chemistry was studied from the Gibbs plot and it can be summarized that precipitation and rock-water interaction are the major factors that influence the groundwater chemistry. The first four factors comprise 83.243% of the total variability of the groundwater samples of the Dharla floodplain aquifer whereas in case of the groundwater of the aquifers of the Tista floodplain first five factors constitute the 81.298% of the total variability of the original data. The study shows the dominance of HCO_3^{-1} in the anionic part of the groundwater. More than 73.68% of the groundwater samples of the aquifers of the Tista floodplain exceed the maximum permissible limit of WHO for arsenic. The groundwater samples from the Tista floodplain especially from some parts of Rajarhat have high concentrations of iron. The first factor of the Dharla floodplain is dominated by iron and HCO_3^{-1} ions which suggests the derivation of iron in the groundwater of the study area from the chemical weathering of siderite (FeCO3).

Keywords: *Groundwater; Gibbs Plot; Factor; HCO_3^{-1} and Siderite.*

1. Introduction

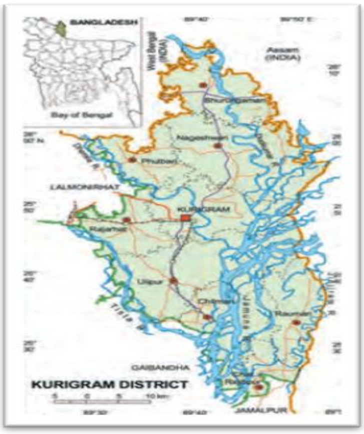

Fig. 1: Map of the Study Area.

Kurigam district is in Rangpur division, Bangladesh (Figure 1). The Quaternary floodplain deposits of the Dharla, Tista and Brahmaputra rivers constitute the shallow aquifers of the district. The aquifers are unconfined to semi-confined in nature. Two right bank tributaries of the mighty Brahmaputra river are the Tista and the Dharla rivers. The Dharla river originated in the Eastern Hamalyas, Sikkim, India and enters Bangladesh through the Lalmonirhat and Kurigram districts of Rangpur Division. The Dharla falls into the Brahmaputra River in Kurigam. The source point of the Tista river is Teesta Kangse glacier of the Eastern Himalayas, Sikkim State of India (Saha et al. 2019). The Tista river enters in Bangladesh through Nilphamari district and empties into the Brahmaputra river near the Fulchari Ghat. These rivers are two major rivers of the Rangpur division of Bangladesh and supply the water for the people of this region. The present research work is taken for the understanding of the groundwater quality of Kurigram district where the groundwater aquifers lie on the floodplains of the Tista and the Dharla rivers. Tectonically, Kurigram district lie in Rangpur Saddle (Rahman et al. 2012). The mean annual rainfall of Kurigram district is nearly 3000 mm (Rahim et al. 2018). The riverine sediments contain feldspar group of minerals (Mazumder et al. 1994: Saha et al. 2019).

2. Methodology

A large numbers of researchers carried out research works on the hydrochemistry of the study area. The present review article deals with the geochemical nature of the groundwater using mainly Gibbs diagram and factor analysis. The analysis of pre-existing geochemical data was performed by the necessary computer software like MS Excel and SPSS-20 and while the data was used the respective research was cited.

3. Results and discussion

The mean pH value of the shallow tubewell waters of Kurigram Sadar is 7.4 (Akter et al. 2016). The pH of the groundwater samples from Rajarhat area increases whose numerical values vary from 7.8 to 8.1 with an average value of 7.9 (Moni et al. 2019). The groundwater samples from the aquifers of the Dharla floodplain, Fulbari Upazila show that the pH values are acceptable for potable and irrigation purposes and ranged 7.4 to 8.7 (Rahman et al. 2013b). The research work of Saha et al. 2019 reveals that the pH of groundwater increases towards the floodplains of the Brahmaputra river, Chilmari, Kurigram.
The EC values of the waters from the Dharla floodplain aquifer vary widely, whereas the highest EC value recorded as 865µS/cm (Rahman et al. 2013b). The EC value of the groundwater samples of Rajarhat Upazila are varying from 99 µS/cm to 200 µS/cm (Moni et al. 2019: Saha et al. 2019). The groundwater in the downstream direction of the Tista floodplain aquifers show an increasing trend in EC values.
The Piper-Trilinear plot of the geochemical data of the groundwater of the investigated areas of Kurigram district show that they are mainly Ca-HCO_3 type and some of them are Na-HCO_3. More than 73.68% of the groundwater samples of the aquifers of the Tista floodplain exceed the maximum permissible limit of WHO for arsenic (WHO 2018: Moni et al. 2019).
Gibbs (1970) plotted a diagram in order to decipher the major natural factors which control the nature of the groundwater and change the hydrochemical concentrations. The diagram shows the relationship between aquifer nature and chemical composition of the groundwater (Balamurugan et al. 2020). The three natural processes include are precipitation, rock-water interaction and evaporation. Figure 2 was plotted by using TDS vs $Na^{+}/(Na^{+1}+ Ca^{+2})$ for the groundwater samples of the investigated area and it was revealed from the diagram that all the groundwater samples fall in precipitation and rock-water interaction zones.

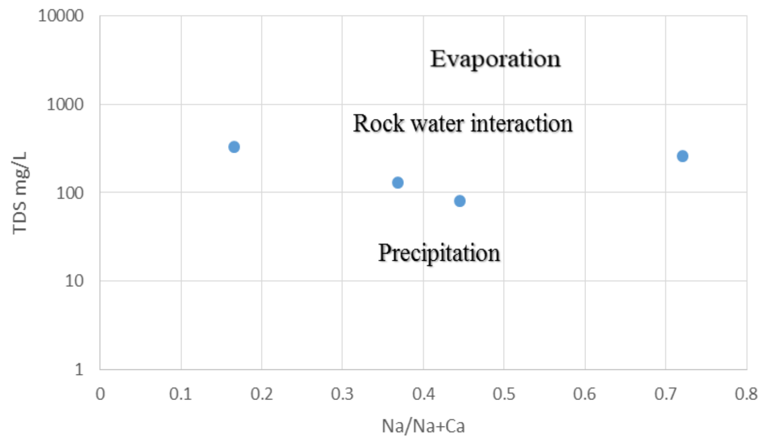

Fig. 2: Mechanism of Groundwater Chemistry.

4. Factor Analysis

Dharla floodplain aquifer

Table 1: Total Variance Explained, Dharla Floodplain Aquifer (After Rahman et al. 2013b)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.082	37.112	37.112	4.082	37.112	37.112
2	2.214	20.127	57.239	2.214	20.127	57.239
3	1.636	14.874	72.113	1.636	14.874	72.113
4	1.224	11.131	83.243	1.224	11.131	83.243
5	.717	6.523	89.766			
6	.528	4.804	94.570			
7	.306	2.786	97.356			
8	.144	1.305	98.661			
9	.107	.971	99.632			
10	.036	.326	99.958			
11	.005	.042	100.000			

Extraction Method: Principal Component Analysis.

Table 2: Component Matrix[a]

	Component Factor-1	Factor-2	Factor-3	Factor-4
Na	-.037	.870	.056	-.239
K	.359	-.300	.753	.079
Mg	-.833	-.326	.340	-.103
Ca	.346	.146	.819	.040
Fe	.575	-.627	-.318	-.145
Cl	-.267	.042	.185	.787
HCO3	.952	.159	.088	.087
SO4	-.437	.214	-.228	.593
CO3	-.789	.062	.288	-.381
F	.326	.871	-.024	-.049
I	.954	-.108	.016	.050

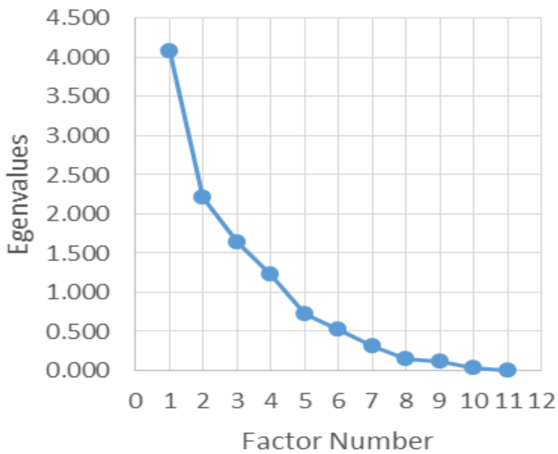

Fig. 3: Scree Plot for Geochemical Data of Dharla Floodplain Aquifer.

As revealed from Table 1, the first four factors comprise the ratios of 37.1129%, 20.127%, 14.874% and 11.131% respectively, and they constitute 83.243% of the total variability of the original data. The first factor (Factor-1) is distinguished by the dominance of iron, bicarbonate and iodine ions of the groundwater and indicates chemical weathering of the iron bearing minerals like siderite ($FeCO_3$). The second factor (Factor-2) shows that the prevalence of sodium and fluorine in the investigated groundwater that might have resulted from the dissolution of sodium rich minerals like sodium halides. The third factor (Factor-3) is highly affected by the contamination of potassium and calcium of the groundwater. The factor-4 is characterized by the presence of anions like Cl^{-1} and sulphate.

Tista floodplain aquifer

Table 3 deciphers that first five factors constitute the ratios of 33.689%, 14.487%, 12.937%, 11.058%, and 9.128% whereas they make up 81.298% of the total variability of the original data of the groundwater samples of the Tista floodplain aquifer. The first factor (F-1) is characterized by the dominance of Ca, F and Fe that indicated the dissolution of calcium and iron-bearing minerals. The second factor (F-2) shows the dominance of nitrate ion and it shows that the shallow aquifer is contaminated from the influx of agricultural and urbanization activities. The third factor (F-3) is distinguished by the prevalence of the Mg and Mn, and indicates the chemical weathering of magnesium-bearing rocks like dolomite and manganese minerals like rhodochrosite ($MnCO_3$). The fourth factor (F-4) is showing the dominance of HCO_3^{-1} which constitute the anionic part of the groundwater. The fifth factor (F-5) is dominated by the presence of the potassium that might have resulted from the dissolution of potassium feldspar minerals and chemical fertilizer.

Table 3: Total Variance Explained, Tista Floodplain Aquifer (After Moni et al. 2019 and Saha et al. 2019)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.043	33.689	33.689	4.043	33.689	33.689
2	1.738	14.487	48.176	1.738	14.487	48.176
3	1.552	12.937	61.112	1.552	12.937	61.112
4	1.327	11.058	72.170	1.327	11.058	72.170
5	1.095	9.128	81.298	1.095	9.128	81.298
6	.878	7.320	88.618			
7	.440	3.670	92.288			
8	.404	3.367	95.655			
9	.239	1.993	97.649			
10	.149	1.239	98.887			
11	.088	.736	99.623			
12	.045	.377	100.000			

Extraction Method: Principal Component Analysis

Table 4: Component Matrix[a]

	Component				
	F-1	F-2	F-3	F-4	F-5
Na	-.582	-.145	.343	.061	.291
K	.077	.428	-.395	.325	.659
Ca	.698	.194	.293	.490	-.271
Mg	-.629	-.034	.727	.060	-.009
Fe	.569	.676	.205	.022	.035
Mn	.526	.022	.641	-.212	.358
As	.477	-.470	.329	-.202	.211
Cl	-.677	.367	.254	.278	-.264
F	.661	-.479	-.111	-.023	-.352
NO3	.388	.625	.113	-.391	-.308
SO4	-.831	-.001	-.017	.170	-.203
HCO3	.501	-.248	.116	.793	-.003

Extraction Method: Principal Component Analysis.

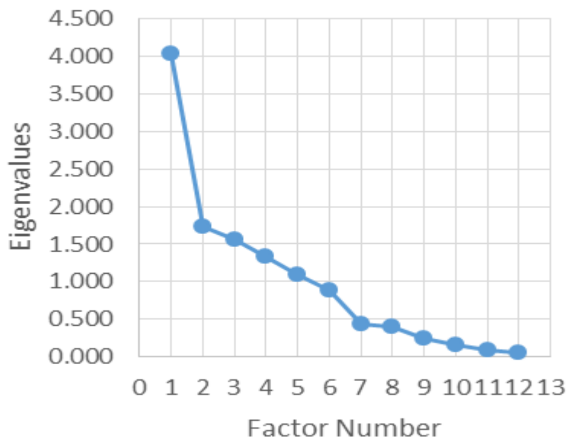

Fig. 4: Scree Plot for Geochemical Data of Dharla Floodplain Aquifer.

5. Conclusion

The present research shows the pH values of the investigated areas of Kurigram district range 7.4 to 8.1 which is suitable for the irrigation purposes. The pH values of groundwater samples of the aquifers of the two floodplains of Dharla and Tista rivers are different. The value of pH increases to the downstream directions i.e. towards the floodplains of the mighty Brahmaputra river. More than 73.68% of the groundwater samples of the aquifers of the Tista floodplain exceed the maximum permissible limit of WHO for arsenic. The Gibbs plot of the TDS vs $Na^{+1}/(Na^{+1}+ Ca^{+2})$ shows the groundwater chemistry of the various aquifers of Kurigram district are influenced by the processes like precipitation and rock-water interaction. The alkalinity dominates the groundwater geochemistry. The waters are mainly $Ca\text{-}HCO_3$ or $Na\text{-}HCO_3$ types. The factor analysis of the groundwater samaples of the Dharla and Tista floodplain aquifers show different distinguishing characteristics. The first factor (Factor-1) of the Dharla river floodplain is distinguished by the dominance of iron, bicarbonate and iodine ions of the groundwater and indicates chemical weathering of the iron bearing minerals like siderite ($FeCO_3$). Further research works can be carried out to study the geochemical and mineralogical compositions of the aquifer materials of the investigated area.

Acknowledgement

The authors are pleased to express thanks to all the researchers whose research works are cited in the present work.

References

[1] Akter T, Jhohura FT, Akter F, Chowdhury TR, Mistry SK, Dey D, Barua MK, Islam, MA and Rahman M (2016) Water Quality Index for measuring drinking water quality in rural Bangladesh: a cross sectional study. Journal of Health, Population and Nutrition 35:4. DOI 10.1186/s41043-016-0041-5. https://doi.org/10.1186/s41043-016-0041-5.

[2] Balamurugan P, Paramasivam SK, Kauppannan S, Ravichandran N, Selvaraj P (2020) A GIS-based evaluation of hydrochemical characterisation of groundwater in hard rock region, South Tamil Nadu, India. Arabian Journal of Geosciences: 13:837. https://doi.org/10.1007/s12517-020-05813-w.

[3] Mazumder QH, Jahan CS, Roy MK (1994) Sphericity and roundness study of the Tista River clastics, Rangpur, Bangladesh. Rajshahi Univ Stud Part B 22:141–152.

[4] Moni SA, Satter GS, Reza, AHMS and Ahsan MA, (2019) Hydrogeochemistry and Arsenic Contamination of Shallow Aquifers in Bidyananda and Nazimkhan Unions, Rajarhat Upazila, Kurigram, Bangladesh. Journal Geological Society of India 94: 395-404. https://doi.org/10.1007/s12594-019-1327-1.

[5] Rahim A, Sultana MS, Ferdous J, Begum A and Islam MA (2018) A Study of Activity Concentrations in Water Samples from Kurigram, Bangladesh. Journal of Environmental Pollution and Management 1:101.

[6] Rahman MM, Reza AHMS, Rahman MM, Islam R, Rahman MA (2013b) Geochemical characterization of groundwater in Bhangamor Union, Fulbari Upazila, Kurigram. Int J Chem Mater Sci 1(2):022–035.

[7] Saha S, Reza AHMS, Roy MK, 2019 Hydrochemical evaluation of the groundwater quality of the Tista floodplain, Rangpur, Bangladesh: Applied Water Science, 9,198. https://doi.org/10.1007/s13201-019-1085-7.

[8] WHO (2018) Arsenic in drinking-water, background document for development of who guidelines for drinking-water quality. WHO, Geneva.