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Major Ion Chemistry of Tenga River at Dahung, Arunachal Pradesh, India

Bidyut B. Sharma and *H. P. Sarma

Department of Environmental Science, Gauhati University, Guwahati

ABSTRACT

This study examines the major ion chemistry of the Tenga River in the Dahung area in Arunachal Pradesh of India. The samplings were carried out during the post-monsoon period and all the analysis were carried out following the standard procedures. Tenga river water is characterised by the following relative ionic abundances: Mg > Ca > Na > K > Fe and SO_4^- > Cl^- > NO_3 > PO_4^-. Hydrochemical analyses indicate that dolomite weathering and dissolution of feldspathoid group and evaporite sediments are the major contributing factors towards the composition of the river water. In the absence of major industrial activity in the region, the other significant impact on water quality of the river is due to the agricultural and livestock operations through farmland runoff.

Keywords: Tenga River, Dahung, Arunachal Pradesh, PCA.

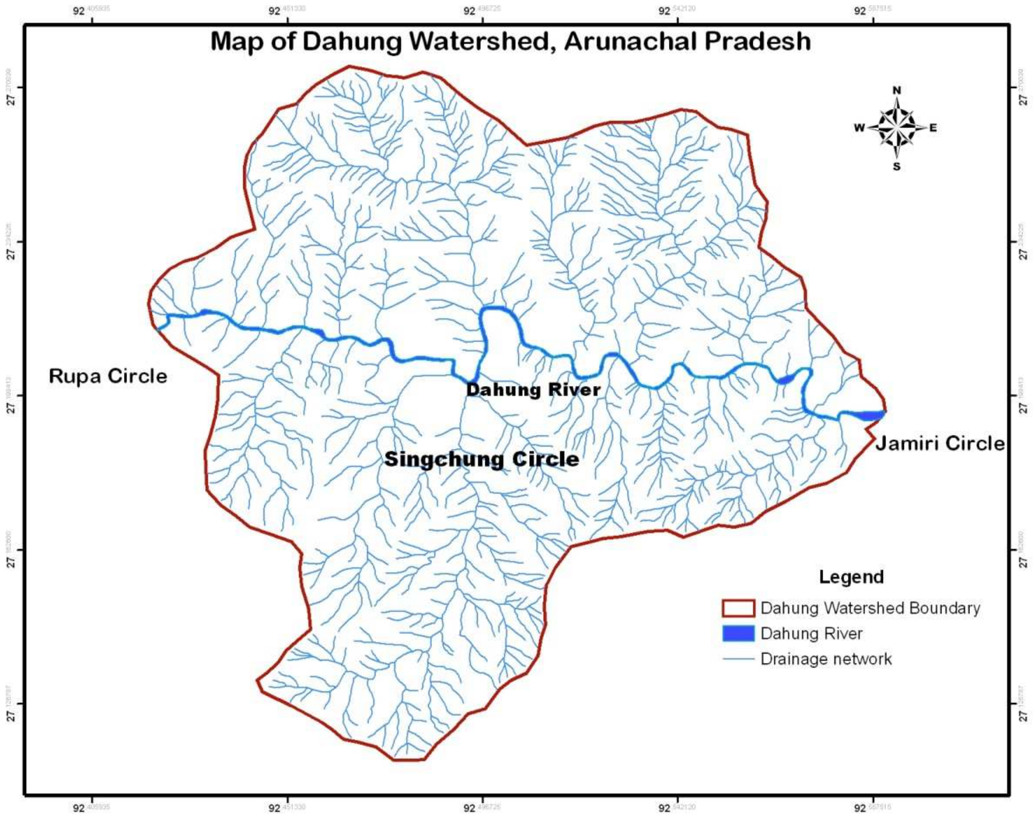
INTRODUCTION

Chemical composition of river water is due to different natural sources which includes precipitation (rainfall, snowmelt), chemical weathering in drainage basins, contribution from springs and aquifers and also due to anthropogenic influences (agricultural activities, waste disposals etc.). Significant information on the sources of elements to the river, their mobility in freshwater systems, estimates on chemical erosion rates and uptake of CO_2 during chemical weathering can be derived from the chemical composition of river water **[1]**. Such data from chemical analyses of river water also provides the basis to assess water quality for domestic, agricultural and industrial usage. In the last few decades, a lot of research has been carried out to study the chemical and isotopic composition of major river basins of the world. In India, also, investigations have been done in major river basins like the Ganga, Yamuna and Brahmaputra **[2 – 6]**. In general, the rivers traversing the Himalayan ranges have attracted more interest in this regard and the main reason cited behind such intensive studies on the Himalayan river basins is to examine whether silicate weathering in the Himalaya is a driver of global change during the Cenozoic period **[1]**. However, such studies are very limited in the high altitude river systems of North-East India Himalayan range. This particularly includes the vast tract of Arunachal Himalayas.

In general, the information on river water quality of Arunachal Pradesh is scanty. We have not come across any such attempt that has been made to analyse the major ion chemistry of Tenga River water. In the present study, an attempt has been made to present the chemical profile of Tenga river water and to interpret the compositional relations in water alongwith the co-genetic behaviour of elements and ions using statistical tools.

The area has not seen any major industrial development and as such, pollution of water resources in the area due to industrial activity can be ruled out. However, the use of agro-chemicals, anthropogenic wastes and chemical weathering of rocks could possibly lead to pollution of water by heavy metals and other toxic compounds.

Study Area:
The Tenga River flow through the Himalayan ranges of Arunachal Pradesh within the Kameng river system. Geographically it flows through Kalaktang, Rupa, Singchung and Jamiri circles in the West Kameng district of Arunachal Pradesh. The Tenga River flows approximately 55 kilometres from Rupa town before joining Bichom River which happens to be a major tributary of Kameng River. Tenga originates from the glacial peaks in the Sakteng region of Bhutan at an approximate location of 27˚18’24.48”N and 91˚59’46.66”E.Geologically, the principal rock type developed in the catchment area of Tenga River comprises of Siwaliks (Tertiaries). Geochemical mapping done by GSI reveals the occurrence of quartzite, dolomite, feldspars and phyllite in the region **[7]**. The samples were collected within the Singchung circle of West Kameng district within a stretch of ten kilometres.



MATERIALS AND METHODS

Methodology:
Water samples were collected during the post-monsoon (November 2009) period from eight

locations along the river at regular intervals. Composite water samples were collected in two sets in pre-cleaned high-density polyethylene (HDPE) bottles (500 ml capacity) from each sampling locations. After collection, the samples were immediately transported to the laboratory and stored in the refrigerator at 4˚C prior to analysis. The methods outlined in Standard Methods for Examination of Water and Wastewater **[8]** was followed for analysis of all the physico-chemical parameters. The different parameters selected for this study and the methods adopted for analysis are shown in the **Table 1.**

Table 1: Methods adopted for analysis of different water quality parameters

Parameters	**Methods/Instruments**
pH	pH electrode (ELICO model)
Electrical Conductivity	Conductivity meter (ELICO model)
Turbidity	Nephelometer
Ca, Cl, Free CO_2, Alkalinity, Total Hardness, DO	Titrimetric method
Mg	Magnesium by calculation
Na, K	Flame Emission Photometric method (ELICO model)
Nitrate, Sulphate, Phosphate	UV-Vis Spectrophotometer (Shimadzu UV Mini 1240)
Iron	Atomic Absorption Spectrophotometer (Perkin Elmer Analyst A200)

Chemical data generated were statistically analyzed using SPSS version 16.0. Multivariate statistical analysis was performed on the chemical dataset using Principal Component Analysis (PCA).

RESULTS AND DISCUSSION

Table 2: Descriptive Statistics of the analysed chemical parameters (at 8 locations)

Parameters	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
pH	6.9	7.3	7.21	.135	-2.190	5.358
EC	163.2	210	177.53	16.87	1.477	.830
Turbidity	3.1	6.6	4.25	1.17	1.255	1.493
DO	6.05	12.97	9.22	2.95	.287	-2.122
FreeCO2	39.6	66.0	55.49	8.56	-.859	.327
Alkalinity	200	260	230.25	20.44	.000	-1.118
TH	216	256	229.75	12.07	1.632	3.453
Ca	24.04	48.09	29.55	8.17	2.040	4.444
Mg	26.33	42.93	38.05	5.15	-1.960	4.771
Cl	24.14	31.24	29.11	2.74	-1.277	.182
Na	6.4	8.9	7.5	.86	.485	-.855
K	2.5	5.2	3.9	1.13	-.323	-2.154
Iron	.35	.878	.546	.21	1.132	-.360
Nitrate	.45	.482	.466	.01	.043	-2.049
Sulphate	34.91	51.934	39.96	5.63	1.636	2.538
Phosphate	.037	.145	.062	.035	2.437	6.346

Table 3: Factor loadings on the principal components for various water quality parameters of Tenga River

	Component			
Parameters	I	II	III	Communality
pH	.266	.926	.047	.931
EC	.853	-.019	.356	.854
FreeCO2	.469	.328	-.747	.885
Alkalinity	.057	.195	.774	.640
Turbidity	-.478	.322	.589	.678
DO	-.373	.420	-.782	.927
TH	.576	-.171	.292	.446
Ca	.138	-.953	.089	.936
Mg	.196	.824	.080	.723
Cl	-.891	-.134	-.358	.940
Na	.171	.247	.744	.645
K	.759	.305	-.209	.714
Iron	.475	.066	-.096	.239
Nitrate	-.862	-.363	.158	.899
Sulphate	-.163	-.906	.020	.848
Phosphate	-.061	.366	-.595	.491
Eigen Values	5.049	3.912	2.835	
%age of Variance explained by component	31.558	24.453	17.721	
Cumulative %age of variance	31.558	56.010	73.731	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 4: Correlation Matrix

Correlation	pH	EC	Free CO_2	Alkalinity	Turbidity	DO	TH	Ca	Mg	Cl	Na	K	Iron	NO_3^-	SO_4^+	PO_4^-
pH	**1.00**															
EC	.191	**1.00**														
FreeCO2	.360	.247	**1.00**													
Alkalinity	.197	.538	-.293	**1.00**												
Turbidity	.049	-.132	-.487	.569	**1.00**											
DO	.239	-.543	.569	-.480	-.119	**1.00**										
TH	-.116	.670	-.004	.204	.097	-.378	**1.00**									
Ca	-.878	.229	-.241	.005	-.241	-.532	.236	**1.00**								
Mg	.782	.162	.231	.112	.287	.298	.344	-.832	**1.00**							
Cl	-.325	-.957	-.259	-.461	.057	.529	-.669	-.076	-.309	**1.00**						
Na	.390	.202	-.538	.375	.269	-.672	-.012	-.202	.188	-.341	**1.00**					
K	.472	.448	.466	-.280	-.379	.046	.492	-.304	.575	-.602	.128	**1.00**				
Iron	.284	.123	.165	-.290	-.464	-.264	-.273	-.034	-.123	-.279	.515	.460	**1.00**			
Nitrate	-.567	-.680	-.680	-.026	.412	.101	-.280	.207	-.360	.753	-.156	-.660	-.492	**1.00**		
Sulphate	-.905	-.156	-.464	-.295	-.156	-.280	.299	.776	-.579	.271	-.274	-.227	-.262	.559	**1.00**	
Phosphate	.125	-.157	.677	-.209	.166	.631	-.134	-.261	.176	.068	-.532	.071	-.090	-.207	-.390	**1.00**

DISCUSSION

The descriptive statistics for the major ion composition of Dahung river water is shown in Table 2. The table indicates that the concentration of pH range from 6.9 to 7.3 and turbidity varies from 3.1 to 6.6 NTU with a mean of 4.25NTU. The conductivity values ranged from a minimum of 163.2 to a maximum of 210 with a mean value of 177.53. The D.O ranged from 6.05 to 12.97 mg/L. Free CO_2 in the water varied from 39.6 to 66.0 mg/L with a mean of 55.49 mg/L. The alkalinity values ranged from 200 to 260 mg/L with a mean value of 230.25mg/L. The TH in water is in the range of 216 to 256 mg/L $CaCO_3$.

Cation and anion analysis shows that the content of Ca^{2+} is between 24.05 and 48.09 mg/L; Mg^{2+} between 26.33 and 42.93 mg/L ; Na^{2+} ranged from 6.4 to 8.9 mg/L ; K^{2+} in the range of 2.5 to 5.2 mg/L; Fe^{2+} is between 0.35 to 0.87 ppm; Cl^- is between 24.14 and 31.24 mg/L; NO_3^- between 0.45 and 0.482 ppm; SO_4^- is between 34.91 and 51.934ppm; and PO_4^- is between 0.037 and 0.145 ppm with a mean value of 29.35mg/L, 38.05mg/L, 7.5mg/L , 3.9mg/L, 0.546ppm, 29.11mg/L, 0.466ppm, 39.96ppm and 0.062ppm respectively. Water is characterised by the following relative ionic abundances: Mg>Ca > Na>K>Fe and $SO_4^- > Cl^- > NO_3 > PO_4^-$.

Principal Component Analysis (PCA) was carried out on the dataset showing the chemical composition of the river water to identify the factors that caused the variance of the dataset. PCA values are shown in Table 3. Only three PCs were extracted which together account for 73.731 % of the total variance in the dataset. In this the first, second and third PC accounts for 31.558 %, 24.453% and 17.721% respectively. The values of three PCs are used to assess the dominant hydrogeochemical process. On the first PC, the factor loadings of EC and K had high positive factor loadings (0.759 – 0.266) and high negative factor loadings for NO_3^- and Cl^- (both > - 0.8). This suggests that the first component is associated with high concentration of ions which results in higher conductivity. Dissolution of silicate mineral (potassium feldspar-orthoclase) might have resulted in higher concentration of K^+ ions in the river water **[9, 10]**. Also, runoff from the fertilizer treated farmlands in the Rupa region and uncontained livestock operations within Tenga valley have significant impact on the water chemistry. PC II showed high positive loading for pH and Mg (0.926 and 0.824 respectively). In the same component, Ca and SO_4 had high negative loading (- 0.953 and - 0.906).This factor suggest the effect of weathering of carbonate and sulphide minerals. Ca^{2+} and Mg^{2+} is the result of Dolomite mineral weathering and SO_4^- results from the dissolution of feldspathoid group and evaporite sediments **[10]**. PC III had high positive loadings for Alkalinity and Sodium (0.774 and 0.744) and high negative loadings for DO and Free CO_2 (-0.782 and -0.747).This component indicates the factors contributing to alkalinity which is due to dissolved CO_2 species, metamorphism of carbonate rocks and also biologically mediated sulphate reduction **[10]**. Sodium ions in water are mainly due to dissolution of the feldspars.

The simple correlation coefficient (r) is a measure of the degree of linear association between any two parameters. For the current dataset, the correlation matrix was derived using statistical software. The correlation matrix for the different water quality parameters for Dahung River is shown in Table 4. From the correlation matrix, it is evident that Total Hardness (TH) has got a positive correlation with Electrical conductivity (EC). Mg has a strong positive correlation with pH. Both Free CO_2 and DO have a positive correlation with PO_4. Again, SO_4 shows positive correlation with Ca and NO_3 has a positive correlation with Cl. The correlation values were significant at 0.05 levels.

CONCLUSION

The river water at Dahung is dominated by Mg and SO_4 ions. The hydrochemical analyses of the river reveal that the weathering of carbonate and sulphide minerals and also dissolution of silicate minerals significantly controls the major ion composition. Principal component analysis establishes the weathering of Dolomite mineral alongwith dissolution of feldspathoid group and evaporite sediments. There is also indication of the impact of agricultural and livestock operations on the water quality of Tenga river within the Dahung watershed.

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