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AN ASSESSMENT OF CHEMICAL WEATHERING BASED ON ION CHEMISTRY OF THE TEESTA RIVER, EASTERN HIMALAYA

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INTRODUCTION

Himalayan rivers are a significant source of water for billions of people. The climate change and rapid receding of glaciers lead to the change in water chemistry and the contamination level of pollutant in the rivers. Thus, monitoring of the river's health are crucial. Teesta river is in the Sikkim state in the Eastern Himalaya, serving as a lifeline for millions of people and representing the Sikkim Himalaya overall fluvial system. However, there is a lack of scientific research on water chemistry compared to the other rivers of Indian Himalaya [1].

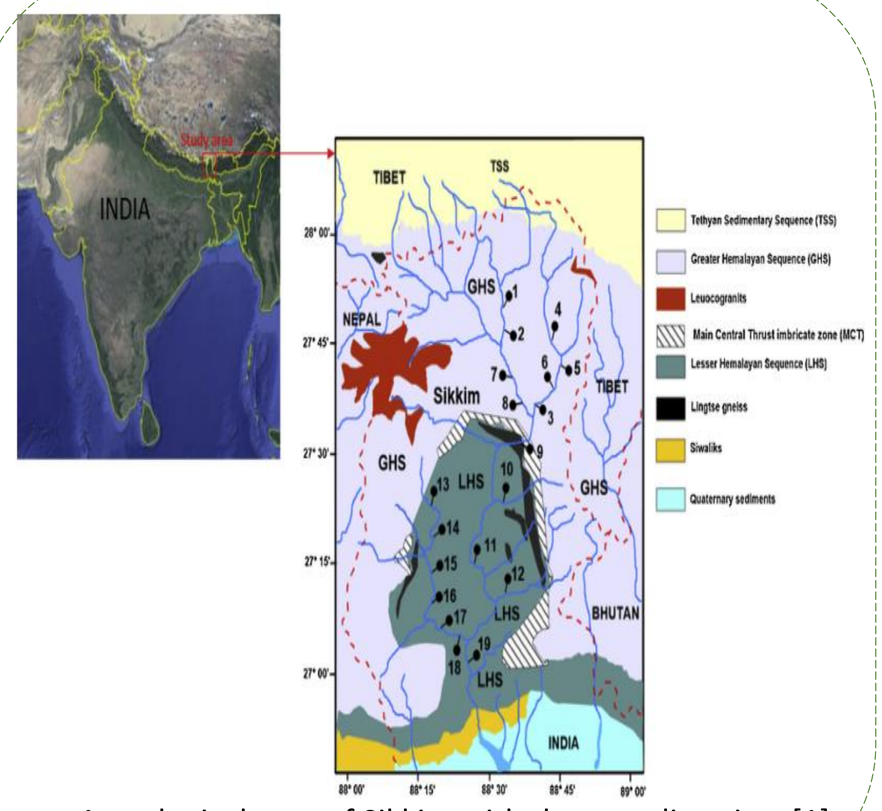
OBJECTIVES

- To study the spatial variations of major ions and trace elements of the Teesta River
- To study the weathering pattern based on the major ions in the Teesta River

EXPERIMENTAL METHOD

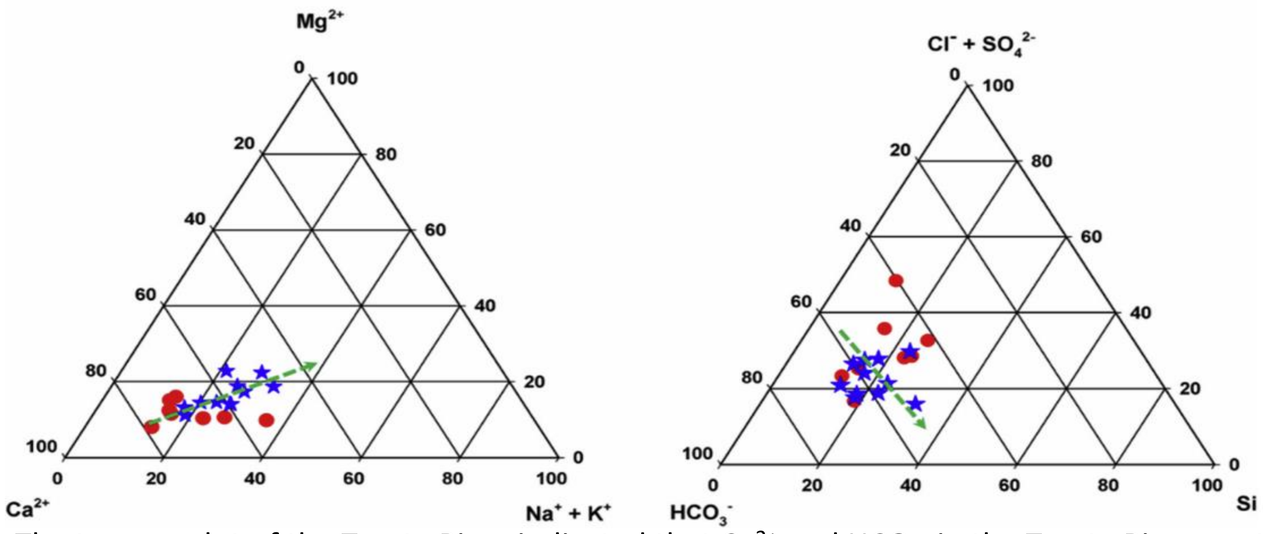
SAMPLING:
- A sampling of the Teesta River was performed in March 2018 and study sites are shown in the map (→)

ANALYSIS:
- Metals were quantified using Inductively Coupled Plasma-Optical Emission Spectroscopy
- Anion analyses are performed using Ion Chromatography

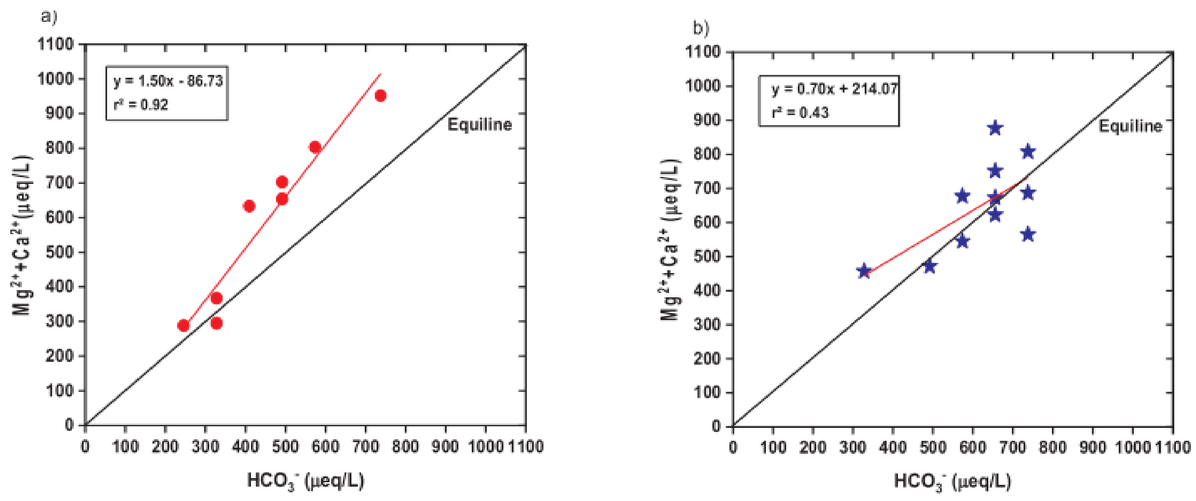


A geological map of Sikkim with the sampling sites [1]

RESULT AND DISCUSSION



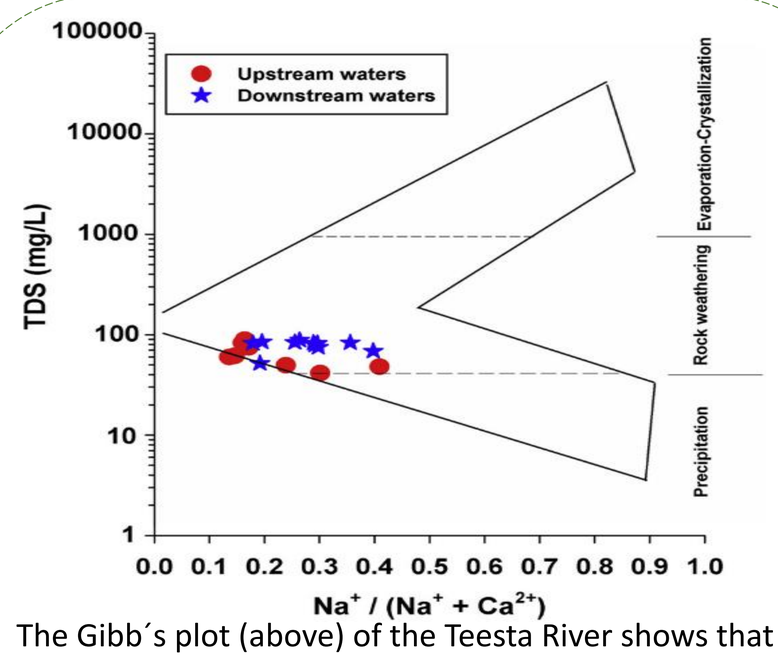
- The ternary plot of the Teesta River indicated that Ca^{2+} and HCO_3^- in the Teesta River are the highest composition. A general tendency of evolution from carbonate weathering to silicate weathering as water flow from upstream to downstream was observed and shown by arrows in the ternary plot above.



- The positive correlation between Mg^{2+}+Ca^{2+} and HCO_3^- as shown in the binary plot above indicates the carbonate weathering at upstream and downstream sites with additional contribution from silicate weathering at the downstream.

- The excess of the stoichiometry of total (Mg^{2+}+Ca^{2+}) than HCO_3^- is likely balanced by SO_4^{2-} from sulphide dissolution [2]. Excess HCO_3– +SO_4 2- over Ca2+ +Mg^{2+} indicates non-carbonate sources (i.e., interaction of H_2SO_4 and H_2CO_3 on silicates) and this excess should be balanced by Na^+ and K^+ that were found in higher amounts than Cl^-

- The rate of silicate weathering is more dependent on the overall balance of key factors including gradient, contact time, temperature and vegetation.



- The Gibb´s plot (above) of the Teesta River shows that the river is governed mainly by carbonate and silicate end-members.

Table: Chemical Guideline value by WHO and BIS

Parameter	Units	WHO[a] (guideline value)	Note	BIS[b](Acceptable limit)	BIS[b](Permissible limit)	Note	This Study[c]
pH	-	-	6.5-8	6.5-8.5	-	-	7.69
Turbidity	NTU	5	-	1	5	-	7.02
TDS	mg/L		-	500	2000	-	66.20
Antimony (Sb)	mg/L	0.02	-	-	-	-	Not detected
Barium (Ba)	mg/L	0.7	-	0.7	No relaxation	-	0.0048
Boron (B)	mg/L	0.5 (T)	-	0.5	1	-	1.01
Cadmium (Cd)	mg/L	0.003	-	0.003	No relaxation	-	Not detected
Calcium (Ca)	mg/L		<250	75	200	-	9.56
Chlorine (Cl)	mg/L	5 (C)	-	-	-	-	1.1
Chromium (Cr)	mg/L	0.05 (P)	For total Chromium	0.05	No relaxation	For total Chromium	0.0015
Copper (Cu)	mg/L	2	-	0.05	1.5	-	Not detected
Potassium (K)	mg/L	-	<250	-	-	-	3.33
Magnesium (Mg)	mg/L	-	-	30	100	-	1.44
Manganese (Mn)	mg/L	0.4 (C)	-	0.1	0.3	-	0.0036
Molybdenum(Mo)	mg/L	0.07	-	0.07	No relaxation	-	0.0029
Nickel (Ni)	mg/L	0.07	-	0.02	No relaxation	-	0.0006
Sodium (Na)	mg/L	-	<200	-	-	-	3.40
Lead (Pb)	mg/L	0.01	-	0.01	No relaxation	-	Not detected
Selenium (Se)	mg/L	0.01	-	0.01	No relaxation	-	Not detected
Sulphate (SO_4^{2-})	mg/L	-	<500	200	400	-	10.24
Zinc (Zn)	mg/L	-	<1	5	15	-	0.3144

[a] WHO guideline for drinking water quality by World Health Organization (4th edition) 2011. [b]BIS Indian standard drinking water specification (second revision) BIS standard 2012. This study[c] means the average values of the measured elements. According to WHO, C is a concentration below or at the given guideline value that might affect the taste, appearance and odour of the water. P stands for provisional guideline value, because there is evidence of hazard but limited information on the effect on health. T is a provisional guideline value because the given value is below the level that can be achieved by practical treatment methods, source protection, etc.

CONCLUSION

- The Teesta River chemistry is mainly governed by natural phenomena, with carbonate weathering at the upstream and downstream is dominated mainly by silicate weathering
- Ca^{2+}, Mg^{2+} and HCO_3 were mainly provided from carbonate weathering while Na^+ and K^+ originated from silicate weathering throughout the entire watershed.
- H_2CO_3 and H_2SO_4 make significant contributions to the weathering process
- The concentration of major ions and elements is in the range of concentration of the global average rivers.
- The Teesta river is pristine with a less anthropogenic contribution to the river´s major ion chemistry.

REFERENCES

[1] Tsering, T., Abdel Wahed, M.S.M., Iftekhar, S., Sillanpää, M., 2019. Major ion chemistry of the Teesta River in Sikkim Himalaya, India: Chemical weathering and assessment of water quality. J. Hydrol. Reg. Stud. 24, 100612. https://doi.org/10.1016/j.ejrh.2019.100612
[2] Krishnaswami, S., Singh, S.K., 2005. Chemical weathering in the river basins of the Himalaya, India. Curr. Sci.