WATER QUALITY OF INDUS RIVER IN THE LADAKH HIMALAYA

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ABSRACT: In the upper Indus, silicate weathering contributes as much as 75% (or even higher in some tributaries) of the total Na and K, reducing to less than 40% down stream parts of the Indus. In contrast, about two-thirds of Ca and Mg in the upper Indus (over 70% in some tributaries) and three-fourth in the lower Indus, are derived from sedimentary carbonates. Finally, the discharge weighted average contribution of silicate derived Ca+Mg and silicate derived Na+K are, respectively, about one-fourth and two-thirds of their total concentrations.

KEY TERMS: weathering, flux, hot spring, lake, fluoride, lithium

INTRODUCTION

Indus River originates near the Mansarovar Lake in Tibet, flows northwestwards through Indus-Tsangpo suture zone, curves around Nanga Parbat massif, enters Pakistan and then flows southwards to the Arabian Sea. The major tributaries of the Indus are the Sutlej, Jhelum, Chenab and Ravi, joining it from the east, and the Kabul, Swat and Kurram from the west . The tributaries joining the Indus in its headwaters are the Shyok, Shingo and Zaskar. The Jhelum, Chenab and Ravi merge with Sutlej before the latter joins the Indus ~ 1000 km upstream of its mouth. In this work extensive sampling of the Indus headwaters and some of its tributaries from the east has been carried out. The drainage area of the Indus is ~ 47 x 10^6 km^2 and its annual water discharge is ~238 km^3. A large fraction of the discharge occurs during the summer season, June to September, which the rivers in the lower reaches intensely experience. The upper reaches of the Indus lies in the rain shadow region of the Himalaya. The climate of Ladakh is semi-Arctic, with the Indus freezing in winter.

Study Area

Samples of Indus river main channel and its head water tributaries (Zaskar, Shyak and Nubra), various small streams, glacial melt water, fresh (Tso Morari) and salt water (Pengong) lakes, Chumatang hotspring, were collected during summer (2000) across the Ladakh Himalaya as mentioned in figure 1.

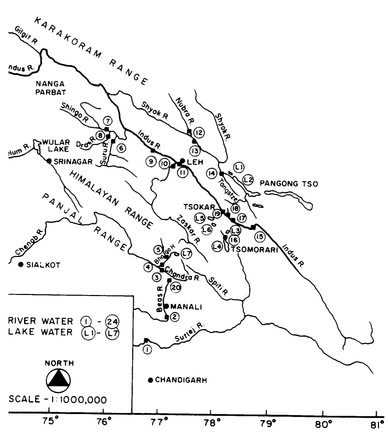

Figure 1: Sample location map (latitude 75° - 80° E; longitude 30° - 35° N).

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Methods

The various nature of aquatic samples from Ladakh Himalayas have been analysed with the help of ion chromatograph for their major ion chemistry. Major ion chemistry of the Indus, and most of its headwater tributaries shown in Table 1 and illustrated in Figure 2, follow the order Ca>Mg>(Na+K) and HCO_3>(SO_4+Cl)>Si. In the Indus River tributaries, however, (Na+K) and (SO_4+Cl) predominate.

Table 1: Major ion chemistry of River Indus and associated water bodies.

	pH	**HCO_3**	**F**	**Cl**	**Br**	**NO_3**	**SO_4**	**Na**	**K**	**Ca**	**Mg**	**Sr**	**Li**	**NH_4**	**TDS**
Glacial Water (n=2)	7.9	117	0.1	1	0.0	0.04	5	2	0.1	32	4	0.02	0	0.0	169
Fresh water lake (=1)	8.5	105	0.1	1	0.0	1	12	1	0.2	36	6	0	0	0.0	171
Tributary to Indus River (n=5)	8.0	75	0.1	3	0.2	1	12	6	0.4	33	6	0.1	0.04	0.5	145
Indus River (n=3)	8.2	82	0.1	5	0.4	1	23	10	0.3	54	12	0.3	0.05	0.0	196
Hotwater Spring(n=1)	8.2	212	49	157	0	1	212	315	3	47	2	1	2	0.0	1009
Hotwater Spring outlet (n=1)	8.3	217	13	137	0	12	294	9	0.2	54	11	0.1	0.1	0.0	756
Salt water lake (n=4)	8.8	290	15	873	7	13	933	1423	16	428	522	0.3	4	0.0	4533
Indus River#	8.1	64	0.2	9	-	-	15	1	2	27	1	-	-	-	122
Indus River Flux* (10^6t yr^{-1})		23	-	3	-	-	5	3	0.4	6	1	-	-	-	-
Indus River Yield* (t km^2 yr^{-1})		4.9	-	0.5	-	-	1.1	0.7	0.1	1.3	0.3	-	-	-	-

note: Values in ppm, except pH

*Indus river flux and yield estimated from the data of Pande et al., 1994

#Subramanian, 1979

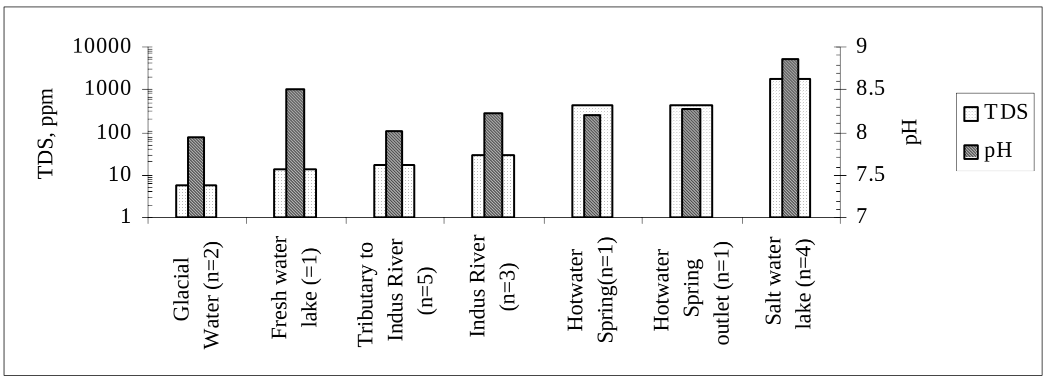
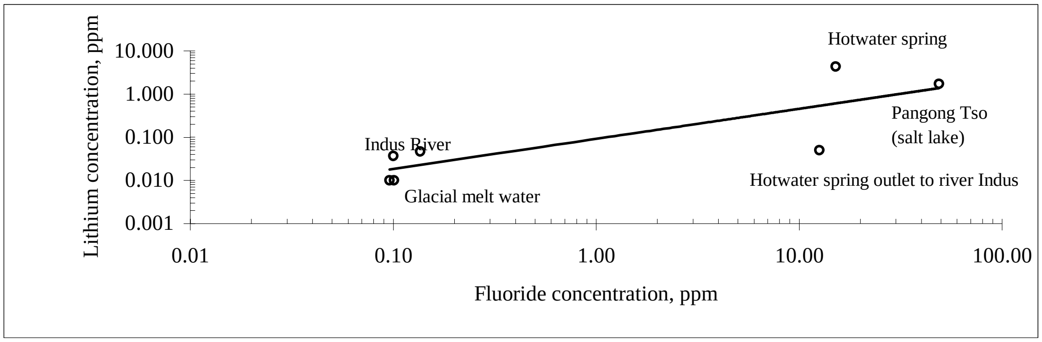


Figure 2: Variation of TDS and pH of various aquatic systems Ladakh Himalaya.

Cyclic salts such as Na constitute about 5% of the annual solutes transported by the Indus. Weathering of two lithologies, sedimentary carbonates and crystalline rocks, controls the dissolved inorganic concentrations and its major element such as Sr throughout the Indus, but turbulent flow and lower temperatures in the headwaters, and storage in reservoirs in the middle and lower Indus promote some equlibration with atmospheric carbon dioxide (Karima and Veizera, 2000). Their Li and Sr concentration range from trace amount in glacial water to high values in salt water lake (Pengong) show with an average of 4ppm Li and 0.3ppm Sr. The earlier studies by Singh et al., (1998) also show low Sr concentrations, and wide range of ^{18}O values are suggestive of their postdepositional alteration in the Ladakh Himalaya. A relationship between lithium versus fluoride is found in the aquatic system and shown in Figure, 3. The value for Sr is generally around 0.2 ppm. The results by Singh et al (1998) show that on the average, weathering of the Precambrian carbonates is unlikely to be a major contributor to the high Sr composition of these source waters; however, they can be a dominant supplier of Sr to some rivers on a regional scale. The Sr component in the source water of Indus (glacial water) is less (0.02 ppm). The calculated Ca/Na, Sr/Na ratios, and strontium compositions of these glacial melts show they represent the silicate endmember. These calculations suggest that Sr in the glacial melt water is silicate origin. The Sr in main channel of Indus is 0.3 ppm and has to be supplied from other sources such as weathering of carbonates and evaporites. This study underscores the importance of weathering of silicates, carbonates, and evaporites in contributing to the Sr concentration and the source waters of

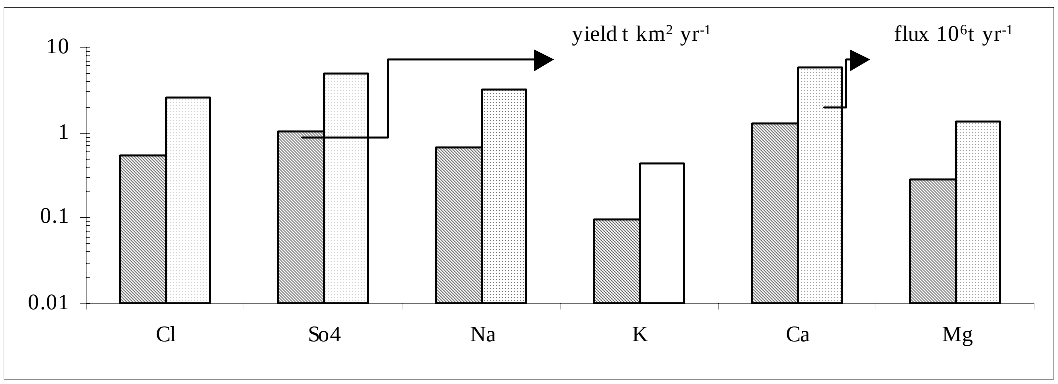


the various smaller glacial melts to the major river Indus.

Figure 3: Relationship between lithium versus fluoride.

Annual chemical flux and solute erosion rate for the major ions of Indus River were calculated and illustrated in Figure, 4. The Indus river basin transport 42 x 10^6 t total annual dissolved flux at a solute erosion rate of 9t km^2 yr^{-1} to Arabian Sea. The maximum rate of flux was found with the bicarbonate, 23 x 10^6 t yr^{-1} at an erosion rate of 4.9t km^2 yr^{-1}. Similarly, Ca has the maximum rate of flux (6 x 10^6 t yr^{-1}) comparing to other cations and show at an erosion rate of 1.3t km^2 yr^{-1}. Further studies on Indus River, suspended sediment and bed sediment analysis is in progress.

Figure 4: Annual chemical flux and solute erosion rate for Indus River.



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