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Glacio Fluvial Sediment Transfer From Chhota - Shigri Glacier (H.P.)

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SYNOPSIS

The glaciofluvial sediment transfer studies were undertaken on chhota-shigri glacier. The glacier lies over the central crystalline of Pir Panjal ranges (Lat 32° 12'-32° 17' Long 77° 30'-77° 32'). Lithologically the entire glaciated valley covered by granitic rocks of different compositions. The meltwater samples for chemical analysis were collected at the portal of glacier during the ablation season of 1987 and 1988. The major cations and anions were determined. The average cationic denudation for the observation period during 1987 and 1988 is 24.86 mequivalent m^{-2} and 11.41 mequivalent m^{-2} respectively.

1.0 INTRODUCTION

1.1 The glacierized catchments in Himalayas with steep rock outcrops lies between 4000 to 7000 meters. This region is an extremely complex mountain system, heavily sculptured by glacial erosion, lithologies range from sedimentary and metamorphic rocks to granite intrusives, the entire region has been subject to extremely complex faulting, folding and overthrusting. The global rates of sedimentation are highly erroneous for the simple reason that the major world rivers are glacier fed and the estimation of sediment and solute input from the glacierised part of the river basin estimation is poor. For example in the Himalayan glacier system the estimates of sediment load vary to tune of one billion to two billion tons per year. Estimation of water quality particularly the rivers belonging to Indus, Ganga and Brahmaputra system is very tentative, because the characteristics of Himalayan glacier watersheds is yet to be understood in detail.

1.2 The present study was undertaken ona transverse type glacier in Lahaul - Spiti valley, H.P. The glacier is known as Chhota Shigri and is about 9 Km. in length. The main objective of the study was to obtain data for sediment and solute transport and the chemical processes operating at the interface of glacier ice mass with bedrock. The traditional view is that the chemical processes are ineffective at low temperature (high altitudes) remains widespread. However, the mounting evidence is in favour of that the meltwarers at the temperature little over freezing point dissolve more CO_2 which enhances the acid hydrolysis thereby accelerating the chemical weathering rates. Number of recent studies have supported this evidence (e.g. Lewis and Grant, 1980; Stednick, 1981; Eyles et al., 1982; Collins, 1983; Dixon et al., 1984; Singh and Kalra, 1984' Raiswell, 1983). Sediment delivery in glaciated basin seem to be highly variable according to geological, glaciological, geomorphological and hydrological factors.

1.3 The proportion of fine sediment in suspension as a wash load is much higher in proglacial streams than in other fluvial environment because of the supply of fine material from glacial erosion processes. The turbulent nature of the flow in streams may also bring coarser material into suspension, and the high viscosity due to low temperature reduces the rate of falling velocities. The large load of suspended sediments at the snout (portal) presents many problems when the water resources of glaciated catchments are developed.

2.0 STUDY AREA

2.1 Location :

The Chhota Shigri glacier lies over the central crystalline of Pir Panjal ranges of Himachal Himalaya (Lat 32^o 12'-32^o 17'; long. 77^o 30'-77^o 32'). It is situated on the right side of Chhota-Dara across Chandra river on the Manali - Kaza road.

2.2 Geology :

Lithologically the entire valley is made up of meso to katazonal metamorphites, migmatites and gneisses intruded in places by granitic rocks of different complexions. The glacier ice mass is overlying the Rohtang Gneisses. Late stage pegmatitic veins are quite common in which feldspar crystals are mainly light grey green in colour.

2.3 Drainage :

The glacier meltwaters emerging at the portal (4000 m) flows in northwest direction and at about 2.5 Km downstream it meets the Chandra river at right angle (Fig. 1). The snout area, however, is covered by a thin layer of debris and there is no surface drainage.

2.4 Discharge Measurement :

By salt dilution method and float method velocity measurements were carried out four times daily. The discharges were computed by using area-velocity method. Then the average daily discharge has been calculated for the use in solute and sediment transport.

3.0 SAMPLE COLLECTION AND LABORATORY METHODOLOGY

3.1 Field samples were collected during the ablation period of 1987 and 1988. Five liters meltwater samples were taken and stored in Polyethulene bottles which were prewashed in distilled water. Immediately on collection electrical conductivity and pH were measured by using a portable Consort C 425 digital pH- conductivity meter. Samples were filtered by using 0.45um Millipore filtration set up in J.N.U. laboratory at Delhi.

3.2 Major cations (calcium, magnesium, sodium and potassium) in samples were determined by using GBC (902) double beam atomic absorption spectrophotometer. Bicarbonate was measured by titration with HCl by taking 4.5 pH as end point. Sulfate was measured by turbidity method on UV spectrophotometer.

3.3 Suspended Sediment Measurements :

Ostrem (1975a) method was used to collect samples. He recommended a narrow necked plastic bottle immersed at an angle of 45^{o} upstream and held in the water for 10-30 seconds. The samples in the laboratory were filtered and the sediment weight was measured per unit volume of water to compute the total sediment load by using discharge measurements.

4.0 RESULTS

4.1 Cationic denudation :

The analysis of major cations and anions presented in the paper based on the chemical data obtained by analysing the meltwater samples collected during the two ablation periods. The solute concentrations recorded near the snout (portal) of the stream during the ablation season consist of a series of repeating cycles that are inversely related to those of discharge. Chemical enrichment may occur wherever water passes over or through subglacial channels. This process is very active where water is in extended contact with materials, this results in solute uptake in meltwaters. Chemical enrichment in supraglacial and englacial surfaces is less than that on subglacial surfaces where glacier grinding has broken down the mineral lattices (Lemmens and Roger, 1978; Gurnell and Fenn, 1985).

4.2 The concentrations of all the cations were computed in milliequivalents/m/day as shown in Table 1 . The plot of daily discharge against yield is shown in Figure 2 . The average cationic denudation of 23 days during 1987 was 24.86 milliequivalents/m/day and for 22 days in 1988 was 11.41 milliequivalents/m/day. The highest denudation figures during 1987 may be obtained as the period of sampling was during the early part of the ablation period and the ionic pockets developed during the pre-ablation period might be flushing out during this period. However, the 1988 sampling period was in the later part of the ablation period and the average daily discharges and denudation processes mught have slowed down. The meltwater samples of the winter flows have not been collected and analysed, therefore, it is not possible to calculate the cationic denudation on yearly basis. A comparative alpine glacier cationic denudation data is shown in Table 2 . This gave further credence to the assertion that the glacierised catchments are experiencing high chemical denudation.

5.0 SUSPENDED SEDIMENT TRANSPORT VARIATIONS RELATED TO DISCHARGE

5.1 Concentration of suspended sediment and the amount of transported matter show great variations with time in meltwater streams - perhaps these variations are greater and occur more rapidly than in any other type of stream (Ostrem, 1975). Figures 3 and 4 show that higher water discharge, in general, carry a larger sediment load than a low discharge. This is the general trend in suspended sediment load pattern from glacierised basins, Gurnell (1982).

6.0 CONCLUSIONS

6.1 The data presented relate to two year observations during the ablation period. The cationic denudation has been calculated provides evidence of profound chemical activity in the Himalayan environment.

6.2 About 70 percent of the annual flow from the glacier basin, occurs between April to October and is mainly due to the show and icemelt. Sediment supplies are commonly flushed out by 'first flood' conditions during July and August in the Himalayas. On both diurnal and seasonal scales, the sediment load is greater on the rising limb of flow hydrograph than on the falling limb.

6.3 The winter meltwater dissolved concentrations and sediment load could not be measured because of logistic problems in reaching Lahul valley.

7.0 REFERENCES

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8.0 ACKNOWLEDGEMENT

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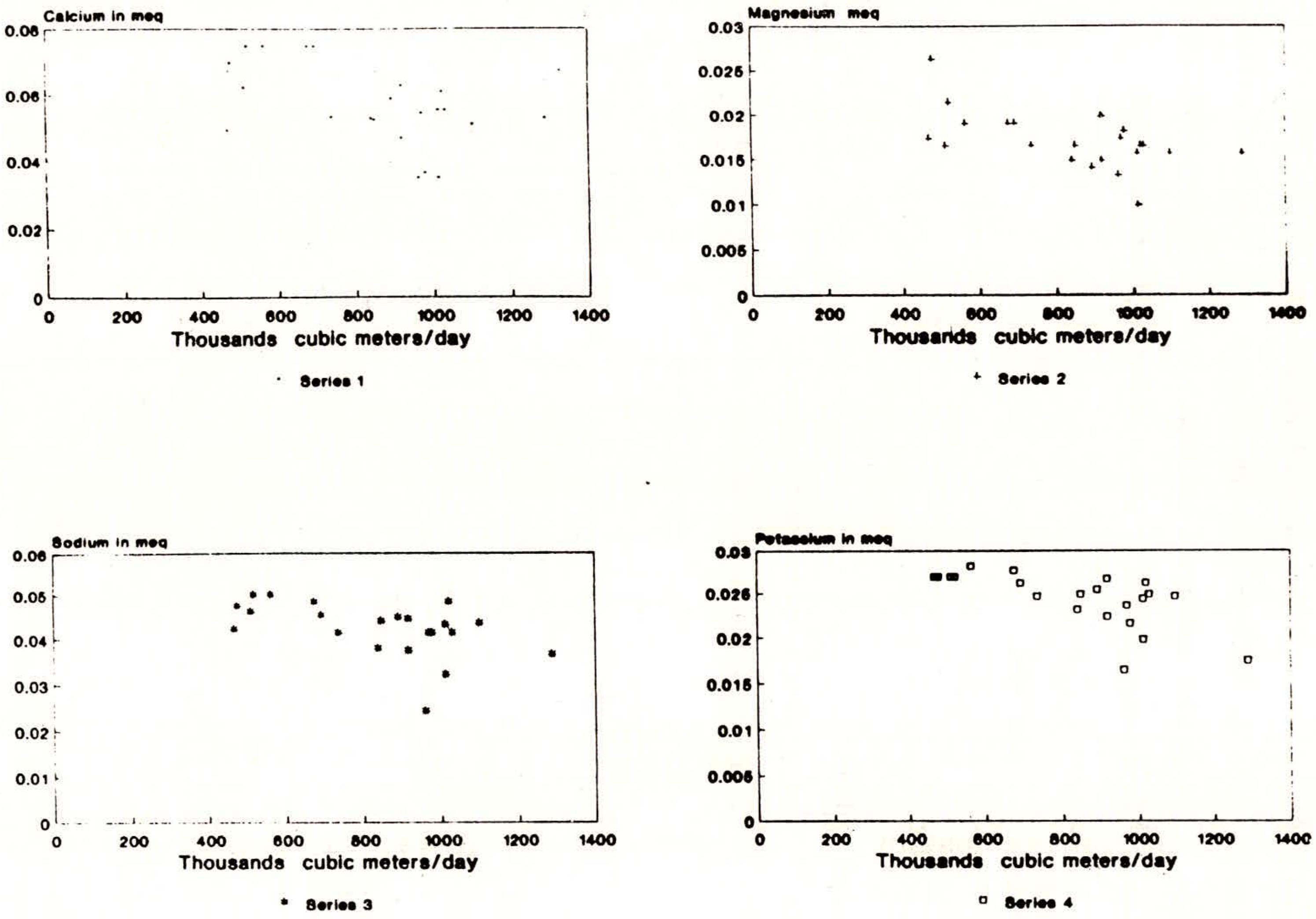
Table 1 : Daily Cationic Denudation Rate

Date	Discharge in 10^6 m^3/ .	(Yield in meq/m^2/Day) EC	Ca^+	Mg^+	Na^-	K^-	Cation
19.07.87	1.002	35.6	13.50	0.99	4.62	3.43	22.55
20.07.87	1.011	46.1	11.80	0.83	3.91	3.50	20.09
21.07.87	1.080	32.5	14.82	1.24	4.23	3.92	24.21
22.07.87	1.425	33.4	25.33	1.52	7.19	6.02	40.05
23.07.87	1.415	28.2	18.95	1.28	5.79	5.33	31.35
25.07.87	1.227	62.4	15.92	1.21	5.44	4.64	27.21
26.07.87	1.201	47.6	15.40	1.09	4.44	3.50	24.43
28.07.87	1.218	62.1	15.62	1.10	5.56	4.05	26.34
29.07.87	1.218	47.9	14.59	1.10	5.67	4.39	25.75
30.07.87	1.278	38.6	14.29	1.05	4.73	3.76	23.83
01.08.87	1.261	32.3	17.88	1.45	4.88	3.74	27.95
02.08.87	1.201	36.7	14.26	0.99	5.33	3.53	24.11
03.08.87	1.132	32.2	14.35	0.93	4.33	3.13	22.73
05.08.87	1.080	36.5	13.42	0.89	4.09	3.12	21.51
07.08.87	1.097	32.7	13.47	2.26	2.91	3.40	22.03
08.08.87	1.158	0027	14.56	1.14	4.08	3.23	23.01
09.08.87	1.322	66.1	16.89	1.20	5.58	4.02	27.68
10.08.87	1.201	69.9	15.16	0.99	4.65	3.13	23.93
11.08.87	1.296	39.6	16.43	1.28	7.83	3.58	29.12
13.08.87	1.054	64.7	13.04	1.21	4.90	2.78	21.94
14.08.87	1.071	31.4	15.66	1.06	5.03	2.90	24.66
15.08.87	1.106	38.6	09.49	0.91	3.22	2.69	16.31
16.08.87	1.106	40.1	12.36	1.09	4.71	2.86	21.02
06.08.88	0.959	40.4	03.35	1.26	2.34	1.57	08.52
07.08.88	1.287	39.6	06.81	1.01	4.70	2.24	15.26
08.08.88	1.011	31.5	03.53	1.00	3.25	1.99	09.77
10.08.88	1.028	35.3	05.69	1.69	4.25	2.55	14.18
11.08.88	1.097	33.2	05.58	1.17	4.77	2.69	14.76
13.08.88	0.916	24.4	04.30	1.36	3.42	2.04	11.11
14.08.88	0.967	27.1	05.26	1.67	4.00	2.28	13.21
16.08.88	0.976	29.8	03.56	1.77	4.03	2.10	11.45
17.08.88	0.915	27.4	05.76	1.81	4.06	2.44	14.06
18.08.88	0.846	46.7	04.44	1.39	3.72	2.10	11.65
20.08.88	0.889	49.3	05.24	1.24	3.99	2.25	12.72
21.08.88	1.019	26.9	06.21	1.68	4.92	2.56	15.46
23.08.88	1.011	45.3	05.60	1.58	4.35	2.46	13.99
24.08.88	0.838	31.6	04.43	1.24	3.17	1.93	10.77
25.08.88	0.734	28.3	03.92	1.21	3.03	1.80	09.97
27.08.88	0.509	46.1	03.18	0.84	2.35	1.37	07.74
28.08.88	0.466	55.9	02.30	0.81	1.97	1.25	06.33
29.08.88	0.475	59.9	03.32	1.25	2.25	1.28	08.10
30.08.88	0.518	53.6	03.88	1.11	2.59	1.39	08.97
01.09.88	0.561	36.7	04.20	1.06	2.81	1.58	09.65
02.09.88	0.674	0035	05.04	1.27	3.25	1.86	11.43
03.09.88	0.691	40.7	05.17	1.31	3.13	1.80	11.41

Table 2

Rates of cationic denudation from other glacierised basins.

Glacier	Cationic denudation
1. Arolla and Ferpecle glacier (Switzerland)	508 meq/sq.m./yr.
2. South Cascade (U. S. A.)	930 meq/sq.m./yr.
3. Continental	390 meq/sq.m./yr.
4. Chhota Shigri (India)	
23 days in 1987	24.86 meq/sq.m./day
22 days in 1988	11.41 meq/sq.m./day


Calcium in meq
0.08
0.06
0.04
0.02
0
0
200
400
600
800
1000
1200
1400
Thousands cubic meters/day
Series 1
Magnesium meq
0.03
0.025
0.02
0.015
0.01
0.005
0
0
200
400
600
800
1000
1200
1400
Thousands cubic meters/day
Series 2
Sodium in meq
0.06
0.05
0.04
0.03
0.02
0.01
0
0
200
400
600
800
1000
1200
1400
Thousands cubic meters/day
Series 3
Potassium in meq
0.03
0.025
0.02
0.015
0.01
0.005
0
0
200
400
600
800
1000
1200
1400
Thousands cubic meters/day
Series 4

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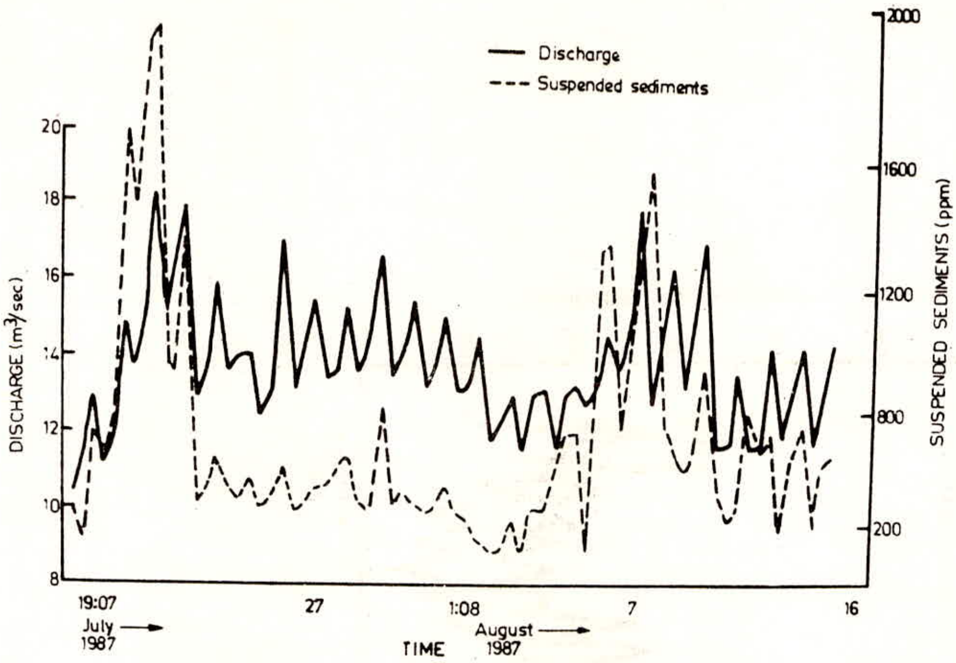

Figure 3

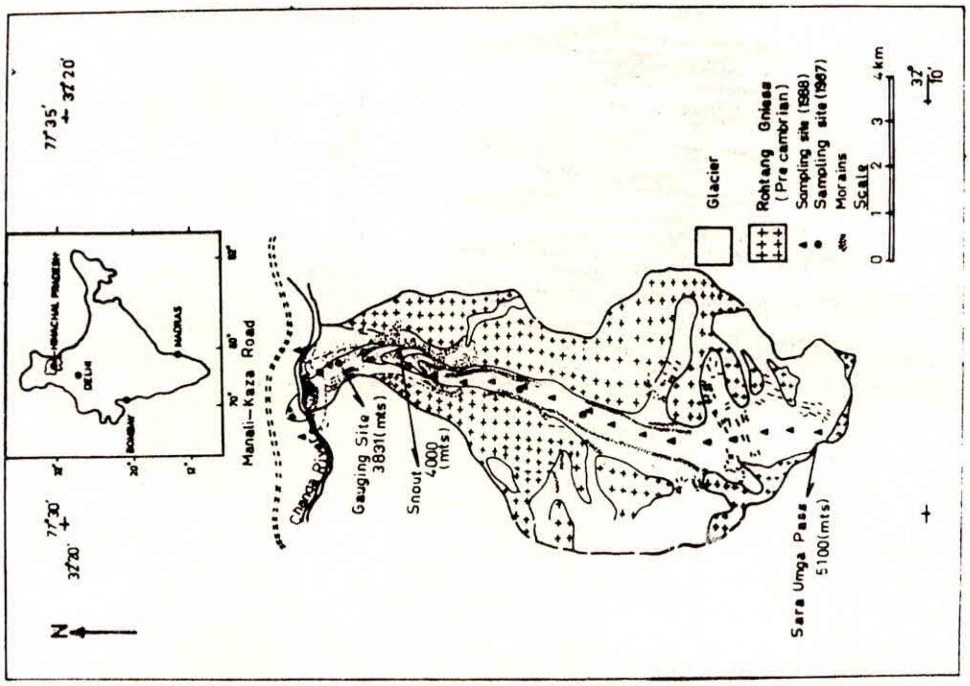

Figure 1

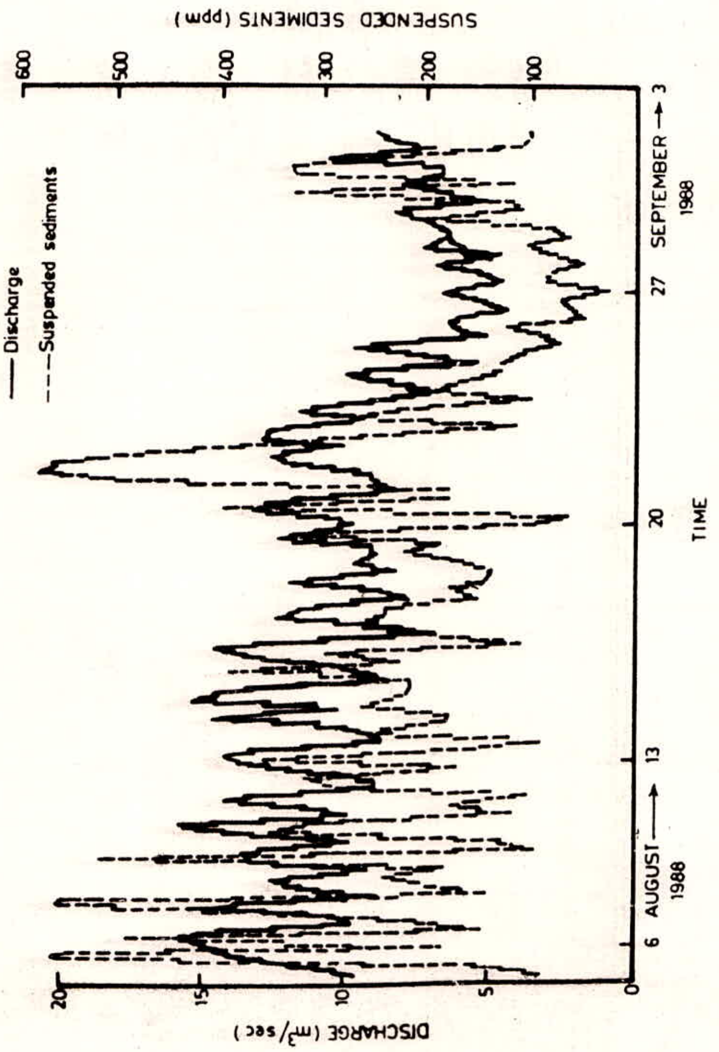
Discharge
Suspended sediments
DISCHARGE (m³/sec)
SUSPENDED SEDIMENTS (ppm)
0
5
10
15
20
100
200
300
400
500
600
6
AUGUST
1988
13
20
27
SEPTEMBER
1988
3
TIME

Figure 4