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Water discharge from the Lirung Glacier in Langtang Valley, Nepal Himalayas, 1996

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Abstract

Discharge from the Lirung Glacier per se was estimated for 6 months from May to October in 1996. The glacier was covered with thick debris, and the direct measurement of the melt rate at the surface is rather difficult. The discharge was hence estimated by measuring the water flow of a river out of the glacier, in which the water budget of a big lake located between the glacier and the observation site was taken into consideration. The discharge increased abruptly near the end of June, and showed the largest value during the monsoon season, July to August. It decreased gradually toward the post monsoon season. The discharge from the glacier and the river flow was similar in seasonal change, but they differed significantly on a daily basis.

1. Introduction

In Nepal Himalayas meltwater from glaciers is important as water resources. It is necessary, therefore, to examine the amount of water from an individual glacier. There are two types of glaciers in the Himalayas, : one is debris free glaciers (Clean type glacier) and the other is debris covered glaciers (Moribayashi, 1974). It is relatively easy to measure the rate of melting for the former glacier, but for the latter type, the direct measurement is usually hindered by the presence of supraglacial debris. It is of use, instead, to measure the discharge from each glacier. This paper presents the discharge data for the Lirung Glacier, one of the debris covered glaciers, from May to October, 1996.

2. Topographical features

The Lirung Glacier is located in Langtang Valley(86°E, 28°N), 60 km north of Kathmandu, the capital city of Nepal. Fig. 1 shows the topographical map of the Lirung basin, for which the area is 13.8 km^2. The ablation area is mostly covered with the debris with the area of 2.3 km^2.

The amount of discharge was measured at observation site in Fig. 1, close to the glacier. The meltwater from the glacier is once collected in a pond near the terminus, and flows out through a river to the Trisuli river, which is the only surface stream from the basin.

3. Runoff Measurement

The measurement was made by using a water level meter MD-8C (CTI. Science Co.) with a resolution of 1 cm with an interval of 1 hour. The water level was also manually measured intermittently, roughly 160 times for the full observation period. The cross section of the river at the measurement site was measured twice in May 28 and November 13, and no discernible change was detected. The mean flow velocities measured as the 60 % water depth velocity were obtained by a Price-type current meter (Sanei Co.), 12 times in the whole period.

The water level, however, was too high for about two months from June to August to measure the mean velocity with the above method. The surface velocity was measured, instead of the mean velocity, since a linear relation was found between them :

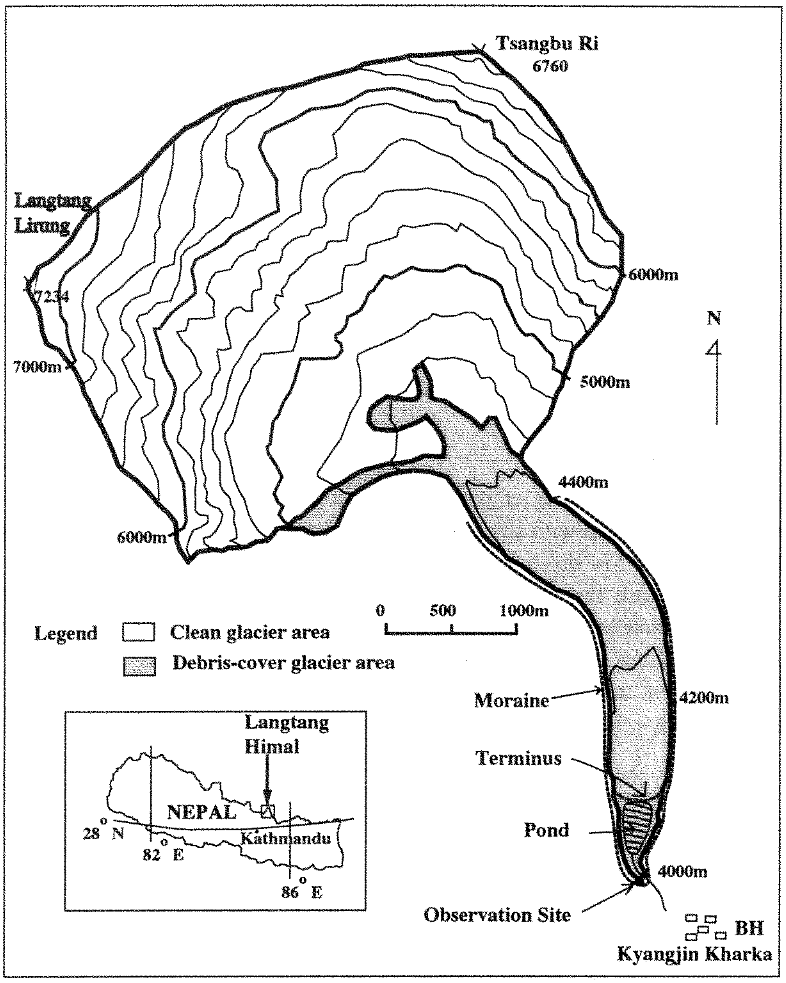

Fig. 1 Topographical map of Nepal and the Lirung Basin.

$$AV = 0.445 \cdot SV \tag{1}$$

where AV is the average velocity for the whole cross section and SV is the surface velocity. The relation between the average velocity and the surface velocity is shown in Fig 2. The discharge was calculated from the mean velocity and the area of the cross section for respective water level. The relation between water level and the discharge is shown in Fig. 3. Regression analysis gives ;

$$Q = 0.0008 \cdot h^2 - 0.0243 \cdot h + 0.8914 \tag{2}$$

where Q is the discharge in m^3/sec and h is the water level in cm. The seasonal change in the discharge was, hence, obtained from the continuous water level data by the use of eq. (2).

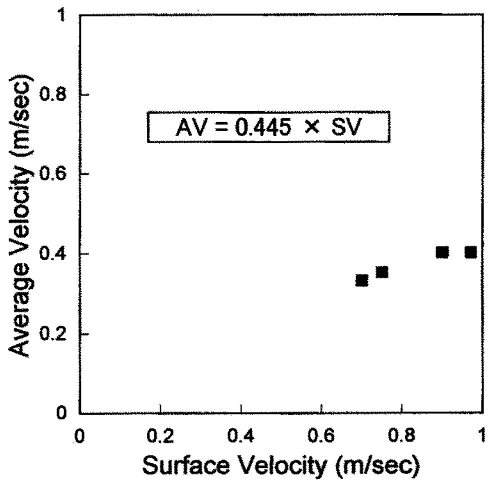

Fig. 2 The relation between the average velocity and the surface velocity.

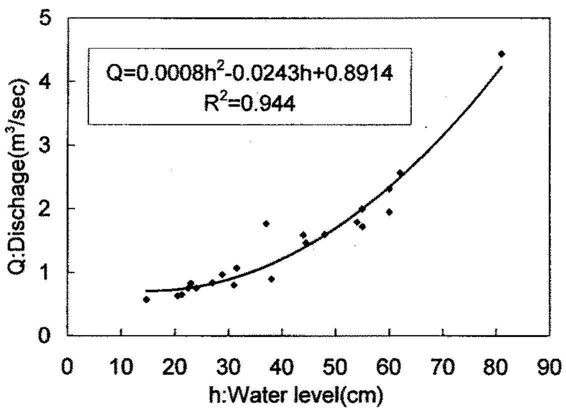

Fig. 3 Stage-Discharge curve at Lirung glacier outlet.

4. Effect of the Pond

The runoff amount measured at the observation site is not equal to the amount of melt water from the Lirung Glacier itself, since the stored water in the pond changes depending on the water level. To estimate the amount of meltwater discharge from the glacier, volume change of the pond has to be taken into consideration.

The pond basin was surveyed using a laser range -finder from bench marks which set on the side moraine. The observation was carried out during the pre-monsoon season when the water level is significantly low. Fig. 4 shows the topographic map of the pond with a contour interval of 10 cm where the level is described referring to the water level given in Fig. 2. The surface area varies as a function of water level as shown in Fig. 5, which covers the water level from 7 cm to 107 cm, the range in the observation period. The surface area of the pond is 36047 m² for 105 cm 2642 m² for 7 cm in water level. The volume difference between the two is 20556 m³.

The precipitation to the pond area only would be hence negligible area of the pond is only 0.26 % to the whole basin area. Therefore, the amount of discharge from the glacier can be calculated as follow ;

$$D=S(L)\cdot\Delta L/\Delta t+Q \tag{3}$$

where D is the discharge from glacier, $S(L)$ is the surface area of the pond for the water level of L, ΔL is water level change in the time interval of Δt, and Q is the amount of runoff water measured at the outlet of the pond. The water level observed at the observa-

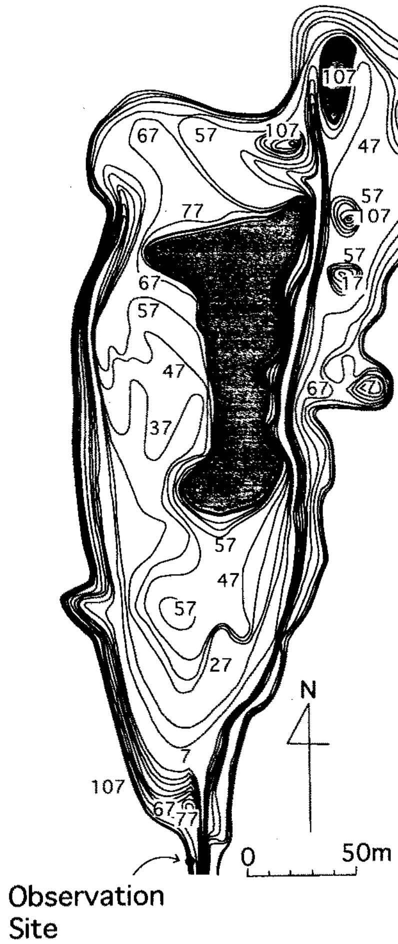

Fig. 4 The topographic map of the pond. The unit of the contours is cm. The level is described referring to the water level given in Fig. 2. and the range is between 7 cm and 107 cm. The gray meshed areas are islets when the water level is 107 cm.

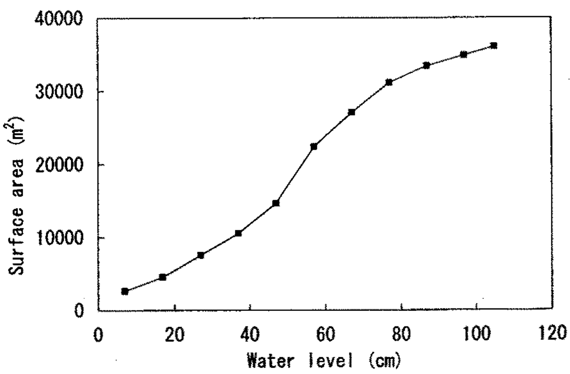

Fig. 5 The relation of water level and surface area of the pond.

tion site was assumed to be the level of the pond.

The discharge from the glacier was thus calculated with eq. (3) and compiled as the daily data. The result is shown in Fig. 6 and Table 1, where the discharge amount is divided by the whole basin area, 13.8 km^2 to give the runoff height. The compiled daily data show that difference between the discharge observed at the outlet and the discharge from the glacier is small.

The discharge from the Lirung Glacier dramatically increases in June, reaching the maximum in the monsoon season from late July to early August. It then gradually decreases until October. The tendency is compatible with the previous observations (Yamada *et al.*, 1984), (Fukushima *et al.*, 1987a), although they have not examined the effect of the pond (Fukushima *et al.*, 1987b).

Fig. 7 compares the converted discharge with the runoff without the modification by eq. (3). In the premonsoon season (Fig. 7a) they appeared the same in post-monsoon season, showing a daily cycle with a maximum in the evening and a minimum in the morning. In the monsoon season, however, the time lag appeared between the two (Fig. 7b). Observed runoff (solid line) was larger than the estimated discharge from the glacier (dotted line) when the water level was decreasing, and smaller with the increasing trend as the effect of the pond. The difference between the two would be compensated when the daily amount is calculated. This would probably the reason why our daily discharge data was compatible

Table 1. The daily meltwater discharge rate from Lirung glacier. (The meltwater discharge rate Q_r (mm/day) is calculated from the basin area, A (km^2) and the amount of meltwater, Q (m^3day) as $Q= (Q_r/A) \cdot 10^{-3}$)

day	May	Jun	Jul	Aug	Sep	Oct
1	–	4.68	–	20.36	20.08	6.16
2	–	4.49	–	23.18	19.37	6.11
3	–	4.44	–	22.35	19.94	5.33
4	–	4.47	–	23.65	17.48	5.40
5	–	4.64	–	23.20	16.62	7.58
6	–	5.16	10.01	23.25	14.21	6.95
7	–	4.50	15.19	25.67	16.62	9.09
8	5.23	4.56	16.19	23.07	17.34	7.87
9	5.48	5.09	21.09	22.87	15.01	7.33
10	6.78	6.37	23.14	21.01	15.21	6.12
11	5.16	7.12	22.07	19.34	16.42	5.20
12	5.88	7.65	20.33	19.58	16.58	5.03
13	4.87	7.88	21.55	28.08	12.87	5.30
14	4.89	8.39	20.76	23.37	11.20	5.01
15	4.44	9.05	21.15	23.46	9.70	5.46
16	5.43	9.16	23.49	19.81	7.73	7.35
17	4.80	10.14	25.24	23.06	8.03	6.70
18	5.46	17.39	24.37	24.98	8.62	6.53
19	5.87	18.35	25.18	18.79	9.64	6.49
20	4.94	20.82	20.49	17.41	9.18	9.01
21	5.12	24.70	19.71	17.15	9.67	8.81
22	5.10	24.11	23.24	15.86	10.04	7.50
23	4.54	21.39	28.88	15.31	10.06	4.43
24	5.34	24.06	26.92	15.30	10.03	4.54
25	7.11	20.75	24.18	15.08	10.54	4.65
26	8.79	22.20	21.55	14.27	9.73	–
27	8.44	21.16	23.07	14.39	12.47	–
28	8.56	21.37	27.40	17.37	15.13	–
29	6.49	–	25.70	16.34	12.50	–
30	5.49	–	23.13	21.62	8.75	–
31	4.85	–	23.55	18.47	–	–
average	5.8	12.3	22.2	20.2	13.0	6.4

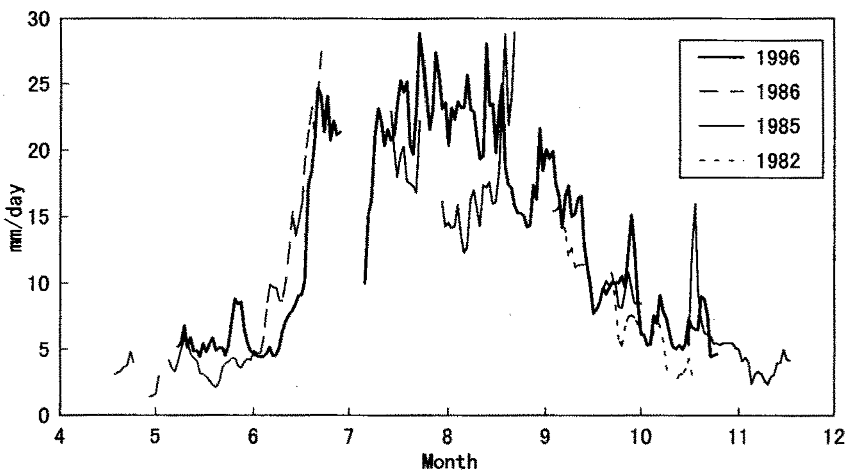

Fig. 6 The variation of the daily meltwater discharge rate from Lirung Glacier. (The meltwater discharge rate, Q_r (mm/day) is calculated from the basin area, A(km^2) and the amount of meltwater is, Q (m^3/day) as Q_r $(Q/A) \cdot 10^{-3}$)

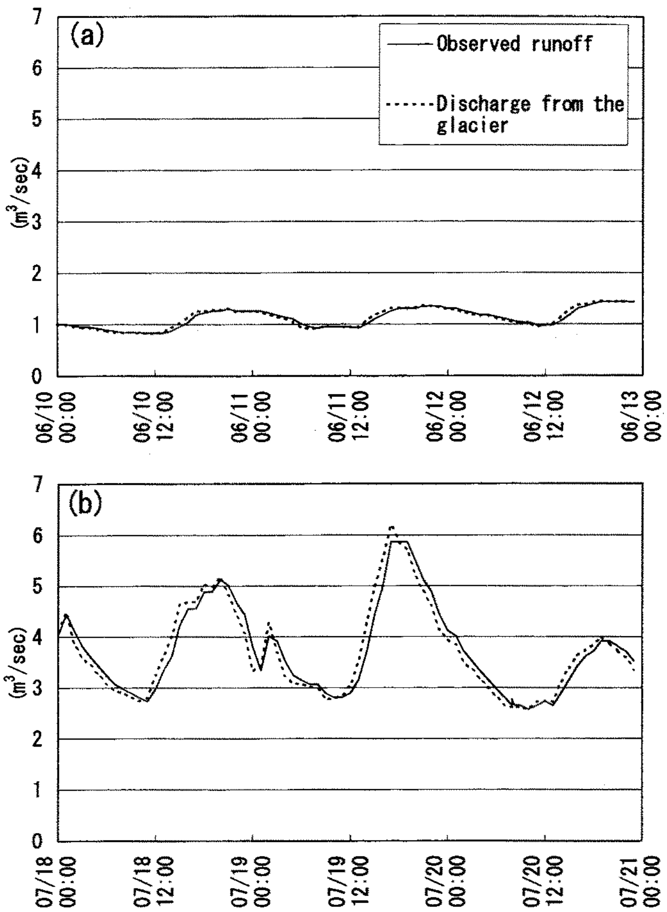

Fig. 7 The daily fluctuations of the runoff amount measured at the outlet of the pond and the calculated discharge from the Glacier in June (a) and July (b) for three days.

with the previous results in which no attention was drawn for the abundance of the pond. When analyzing the daily variation, however, the effect of the pond has to be taken into consideration.

Acknowledgments

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