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Nutrient Transport by Glacial Meltwaters on Svalbard

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Estimates of bio-limiting nutrient fluxes draining glacierised ground are few in number. This study investigates solute characteristics of snow and meltwater in two glaciated catchments on Svalbard to provide details of N and P transport and to determine nutrient fluxes to receiving waters. Nutrient budgets presented below will be used as a basis to identify controls on nutrient behaviour during transport to the fjord environment.

Two study catchments close to the research settlement of Ny-Ålesund, north west Svalbard, were studied: Austre Brøggerbreen, a valley glacier comprising entirely of ice below freezing (cold based) and Midre Lovénbreen, a glacier with a significant proportion of ice at the pressure melting point (polythermal). Glacier thermal regime is known to be important with respect to major solute dynamics in glaciated catchments (Tranter et al., 1996). Here we investigate whether this holds for nutrients. The two study glaciers have virtually identical mass balance records, making them ideal for comparison in this manner.

Inputs to the system were constrained by a survey of the winter snowpack undertaken in April 2000, when bulk snow samples were collected from 30 pits on each glacier, and from sampling of bulk precipitation during summer fieldwork. Meltwater samples were then collected from major proglacial streams during the ablation season (June-August 2000) to estimate nutrient outputs. All samples were analysed for N and P in their various forms and flux estimates were calculated from the product of the daily discharge volume and the sample concentration summed over the entire monitoring period. Detailed nutrient budgets are shown in Table 1.

Table 1. Nutrient budgets calculated for both glaciers during 2000

	Austre Brøggerbreen					**Midre Lovénbreen**				
Component	Water balance (m)	NH_4-N	NO_3-N	TIN	TP	Water balance (m)	NH_4-N	NO_3-N	TIN	TP
Deposition										
Winter/ Spring	0.45	8.93	11.64	20.56		0.452	8.09	10.0	18.09	
Summer	0.039	1.67	5.05	6.72		0.043	1.79	5.41	7.2	
Ice melt	0.112	0.11	0.114	0.24		0.246	0.25	0.32	0.57	
Outputs										
Runoff	0.601	4.98	26.87	31.85	48.4	0.741	3.43	20.73	24.15	396
Difference*[1]	+0.112	-5.73	+10.1	+4.3	+48.4	+0.246	-6.7	+5.0	-1.7	+396

*[1] +ve denotes excess in proglacial runoff over inputs; -ve denotes deficit. TIN represents Total inorganic N; TP represents Total P. All units are elemental fluxes in kg km^{-2} $year^{-1}$. Firn storage is negligible due to high elevation of snowline and low concentrations in residual snowpack.

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Table 1 reveals that Total P export greatly exceeded input in both catchments. Levels of dissolved P (orthophosphate) in inputs and outputs were found to be below detection limits, with virtually all P associated with sediment particles.

The dramatic difference in P flux between the two glaciers is believed to be due to the presence of subglacial drainage at Midre Lovénbreen, which released large volumes of highly turbid water in the second half of the melt season. Data from Midre Lovénbreen (Figure 1) therefore shows positive relationships between total P and discharge and Total P and turbidity, indicating that increased P flux is associated with periods of high flow and high suspended sediment concentration.

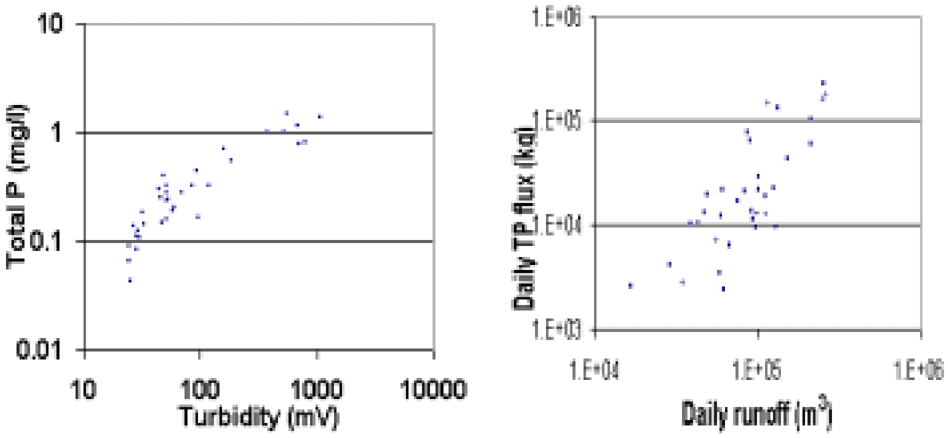

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Figure 1. Scatter plots showing the association between (A) turbidity and Total P concentration and (B) discharge and daily Total P flux at the major Midre Lovénbreen proglacial stream during 2000.

Peak values of discharge and turbidity in Figure 1 reflect the impact of subglacial drainage at this sampling location. Bioavailability of this nutrient therefore appears to be controlled by adsorption to sediment particles and their subsequent removal.

Implications of this study are that nutrient release to ice-marginal waters is sensitive to changes in water flux during deglaciation. Furthermore, it has been found that glaciers are the locus of significant internal nutrient cycling processes.

Reference

Tranter, M., Brown, G.H., Hodson, A.J. and Gurnell, A. 1996. Hydrochemistry as an indicator of subglacial drainage system structure: a comparison of alpine and sub-polar environments. *Hydrological Processes* 10; 541-566.