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BG1.8 High latitude biogeochemistry: Addressing challenges in GHG, from in situ to remote sensing

Remineralization of soil-derived dissolved organic carbon in the high Arctic fjord (Kongsfjorden)

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Introduction

The increased permafrost thawing intensifies the transport of dissolved organic carbon (DOC) from land to Arctic fjords. It has been estimated that the permafrost surface layer contains as much as 1035 ± 150 Pg of organic carbon (Hugelius et al., 2014), so even a small release can significantly change the carbon loads reaching the fjords. Although there are quantitative estimations of the DOC delivered from land, the fate of the soil-derived DOC in fjords remains highly unknown. It is still unclear to what extent this DOC pool is bioavailable and how fast can it be remineralized.

Research objectives

- to quantify the share of labile (DOC_L), semi-labile (DOC_{SL}), and refractory (DOC_R) fractions in the soil-derived DOC,
- to estimate remineralization rate constants (k) and half-life times ($T_{1/2}$) for bioavailable fractions of DOC.

This was done through the 180-days-lasting incubation experiments, in which the soil leachates containing terrestrial DOC have been mixed with the seawater from the adjacent fjord to simulate *in situ* conditions.

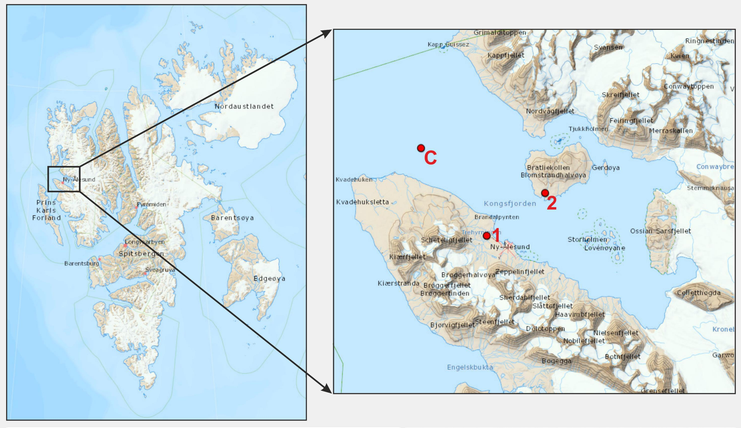

Fig. 1. Map of the study area with photos from sampling stations: 1 - Bayelva River, 2 - Londonelva River and C – control (surface seawater).

Study area

The study has been performed in two contrasting sites in Kongsfjorden – the high Arctic fjord located in West Spitsbergen, Svalbard.

Bayelva River region – characterized by a glacierised catchment area of 32 km², of which 50% is covered by the cold-based valley glaciers. The area is almost entirely underlain by permafrost with a seasonal active layer (Killingtveit, 2004). Bayelva is fed by glacier melt, snow melt, rainfall, and ground ice melt.

Londonelva River region - located on Blomstradøya and characterized by a small (0.7 km²) de-glacierised catchment area, which is almost entirely underlain by carbonate rocks (karst). Londonelva is fed by snow melt, rainfall, and ground ice melt.

Data interpretation

To quantify the DOC remineralization during the experiment, the first-order kinetics was applied, which assumes that the DOC concentration changes over time depending on the initial DOC concentration (time t=0) and the k. The use of this assumption was possible as the experiments were carried out in aerobic conditions.

$\frac{dDOC}{dt} = k \cdot DOC_{(t=0)}$ where: $\frac{dDOC}{dt}$ – change of DOC concentration over time; k – remineralization rate constant.

Results

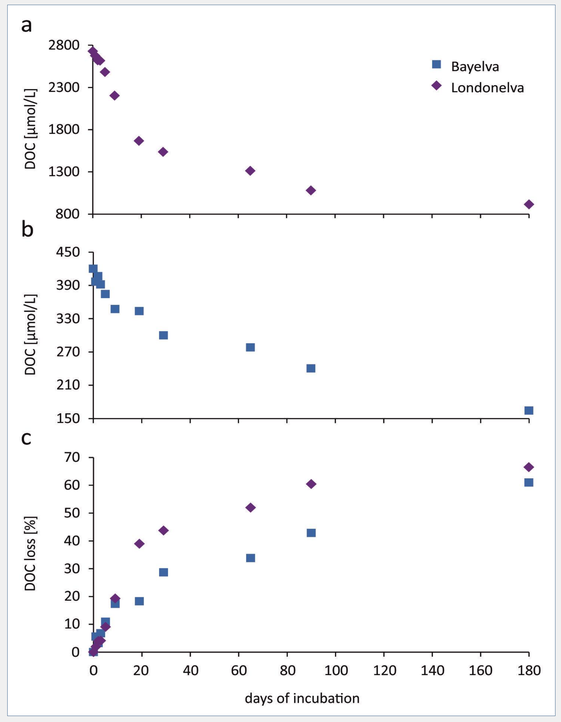

Fig. 2. The decay of soil-derived DOC during incubation (a and b), cumulative losses of soil-derived DOC during the incubation presented as a percentage of initial concentrations (c).

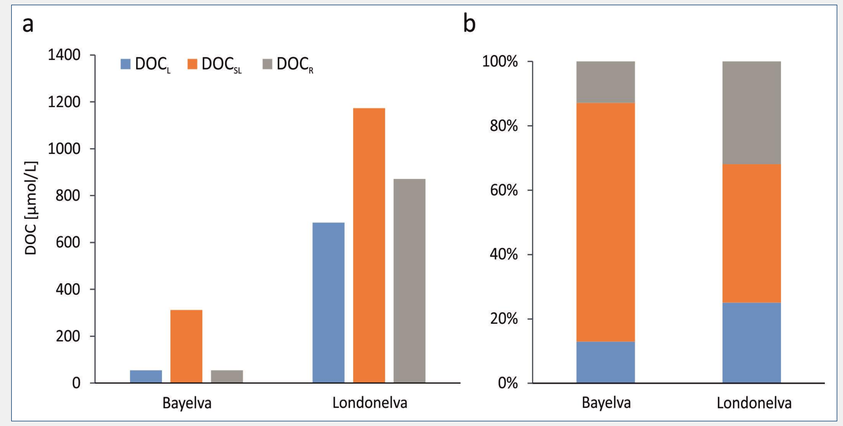

Fig. 3. Concentrations (a) and relative contributions (b) of labile (DOC_L), semi-labile (DOC_{SL}) and refractory (DOC_R) fractions of soil-derived DOC in the soil leachates from the Bayelva and Londonelva catchments.

Tab. 1. Remineralization rate constants (k) and half-life times ($t_{1/2}$) of semi-labile (DOC_{SL}), labile (DOC_L) DOC for Bayelva and Londonelva sampling stations.

Station	DOC fraction	T experiment = 22°C		T melt season = 2.2°C	
		k [days^{-1}]	$t_{1/2}$ [days]	k [days^{-1}]	$t_{1/2}$ [days]
Bayelva	DOC_L	0.194	3.6	0.115-0.029	6-24
	DOC_{SL}	0.006	121.6	0.003-0.001	206-822
Londonelva	DOC_L	0.078	8.9	0.046-0.012	15-60
	DOC_{SL}	0.018	38.5	0.011-0.003	65-260

Conclusions

- soil leachates contain a lot of DOC, which is highly bioavailable, even 68% (Londonelva) and 87% (Bayelva) can be susceptible to biodegradation,
- contribution of the most labile DOC fraction is small and ranges from 13% in the Bayelva region to 25% in the Londonelva catchment, but it remineralizes quickly - within days or weeks, while the semi-labile DOC, whose half-life is measured in months, is much more abundant,
- there are significant differences in the contribution of particular DOC fractions between stations, which can result from the different composition and provenience of organic matter as well as different times of their exposure prior to sampling,
- higher DOC losses, compared to previous studies, indicate that incubation experiments should take into account the significant contribution of semi-labile DOC, whose half-life is measured in months, therefore too short experiments may underestimate the bioavailability of DOC.
- determined remineralization rate constants for both the labile and semi-labile fractions of DOC may be directly applicable in biogeochemical models used in the Spitsbergen region.
- high lability of terrestrial DOC indicates that its supply to the fjords water column has the potential to play an essential role in sustaining the bacterial loop in the fjord and, through CO_2 release, in amplifying ocean acidification in the coastal zone.

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