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# Release and Transport of Toxic, Mobile Organic Compounds (Formaldehyde and Phenols) on an Arctic Glacier

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**Abstract**

As a result of current deglaciation, the chemical cycles of many compounds, including toxic formaldehyde and phenols, are changing. However, the processes by which these chemicals are released have yet to be studied *in situ*. Here, we quantify fluxes of HCHO and phenols in a glacial catchment within one summer season, obtaining a net release from the glacier of $0.106 \cdot 10^6$ g formaldehyde and $0.255 \cdot 10^6$ g phenols, which can be interpreted as a combined result of summer deposition and glacier ice melt. Formaldehyde flux was shown to increase by 164% on a 250 m stretch of the stream flowing through an icing (an exposed former glacier bed area), whilst phenols have shown a smaller increase of 48%. Hence, the importance of glacial forefields in chemical cycle of toxic compounds is pronounced and requires further attention.


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*Keywords:* Formaldehyde, phenols, ice, glacier forefield

## 1. Introduction

Arctic glaciers currently undergo rapid melting [1], [2], upon which they release organic matter influencing downstream ecosystems in two ways: supporting them with labile organic carbon as a nutrient [3] and discharging toxic organic compounds [4].

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Potentially harmful compounds include formaldehyde and phenols [5], which also represent different levels of solubility in water, both being considerably mobile species. Formaldehyde is known to be produced in snowpack and upon photolysis to release OH radicals, influencing the atmospheric lifetime of many chemicals. When incorporated into ice, its concentrations can be used to draw conclusions regarding the past atmosphere oxidizing properties (e.g. [6]). Whilst the snow-atmosphere exchange has been studied thoroughly to obtain information on the ice core record interpretation [7], the processes of release from snowpack upon melt and subsequent *in situ* refreezing into superimposed ice, or removal with meltwater have yet to be studied. This will aid further understanding of its mobility in times of rapid glacier melt.

Phenols originate not only from industrial sources, but also from plant lignin [8], and have been reported in glacial settings (e.g. [3]). The behaviour of phenols upon ice formation has only been studied in laboratory conditions [9], yet on a glacier environmental agents would also play a role, such as glacial ecosystem activity [10], [11] and interactions with mineral grains. Therefore, to assess the impact on ecosystems of the formaldehyde and phenols released from glaciers, an *in situ* study is crucial.

Here, we assess the fluxes of formaldehyde and phenols in proglacial watercourses for the first time, and compare those to the content of both compounds supplied with snow. In doing so, we gain an insight into the release of these potentially toxic chemicals from glacial ice. An estimate of the temporary capture into superimposed ice is also presented in this paper.

## 2. Methods

The samples were collected on Foxfonna, a small cold-based glacier located near Longyearbyen in Svalbard. In total, 13 snow cores and 38 meltwater samples were taken between 12$^{th}$ June and 16$^{th}$ August 2012. Meltwater was sampled on a proglacial river (F1 site, 18 samples) and two proglacial streams directly at the glacier snout that merge into this river after 250 m stretch of flow through an icing (F2 and F3, 10 samples at each site).

In the field, snow water equivalent (SWE) measurements were taken for each snow sample using spring balance. The discharge (Q) in all sites at the time of sampling was measured using the salt dilution technique; the proglacial river was also monitored continuously for water level. The monitoring results will be described further in a forthcoming paper on organic carbon balance of the Foxfonna glacier.

Stream and river water was collected in the field using 1L HDPE bottles, triple rinsed with the sample. Snow cores were taken using a Kovacs 9 cm aluminum ice corer, operated manually and washed with 18 MΩ water before each use. The samples were then collected into pre-washed zip-lock bags, melted in temperature <10°C, and an aliquots of agitated samples were stored in 4°C until analysis.

Both formaldehyde and phenols concentrations were determined using spectrophotometry (Spectroquant PHARO 100, MERCK), with detection limits (LOD) of 0.02 $mg \cdot L^{-1}$ and 0.025 $mg \cdot L^{-1}$, respectively. As quality assurance we employed blank checks, standard solution analysis and triplicate sample runs.

Fluxes were estimated using averaged concentration (c) of a particular species and Q sums estimated from the proportion between the continuously monitored site Q and the Q on glacier snout streams on corresponding dates. Arithmetic mean was found appropriate due to no correlation between c and Q in any site. For flux calculation purposes, c values below LOD were assumed to be equal to half of the LOD.

## 3. Results

The deposition of both species in snow was highly variable (Fig. 1), with outliers potentially dominating the vertical pattern. Overall, the sum of phenols supply was diminishing with decreasing elevation on the glacier, while the opposite was true for formaldehyde. Since the lower part of the glacier melts first, this