Multi-tracer approach for characterizing rock glacier outflow

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Abstract

The present study used a multi-tracer approach (water stable isotopes, electrical conductivity (EC), and major, minor, and trace elements) to identify the impact of rock glacier outflow on water quality. Springs and streams/creeks fed by rock-glaciers were selected in the Upper Sulden and Zay catchment, South Tyrol (Eastern Italian Alps). Preliminary results indicate that all waters sampled in the study area derived from Atlantic water vapour as water source. Melt waters emerging from rock glaciers showed typical ice melt isotopic signatures (δ^2H: -91 to -105‰) and relatively high EC (380 to 611µS cm^{-1}). Preliminary results indicate that EC, Sr, and As concentrations could be used to differentiate rock glacier melt waters from stream waters.

Keywords: permafrost thawing; water stable isotopes; heavy metals; ecological communities; alpine rivers; glacierized catchment

Introduction

Current warming in high mountains leads to increased melting of snow, glacier ice and permafrost. In particular rock glaciers, as a common form of mountain permafrost, may release contaminants such as heavy metals into the stream during summer (Thies *et al.*, 2007). Permafrost thawing may have strong impacts on both water quantity and quality of fresh water resources, with potential consequences on alpine stream ecology. However, only few rock glacier studies using multi-tracer approaches were carried out in the Alps. At the regional scale (South Tyrol, Eastern Italian Alps), high concentrations of Ni were found in meltwater from the Lazaun rock glacier in the southern Ötztal Alps (Krainer *et al.*, 2015; Mair *et al.*, 2011) or lake water in contact with Rasass rock glacier in Vinschgau valley (Thies *et al.*, 2007). These observations call for characterizing rock glacier outflows by means of hydrochemical characteristics. For example, Carturan et al. (2016) used spring water temperature as significant indicator to identify permafrost distribution.

Material and methods

Study area

The present study was located in the glacierized Sulden catchment (130 km^2) in South Tyrol (Italy). The site ranges in elevation between 1110 and 3905 m a.s.l. and has a glacier extent of about 17.7 km^2 (14% of the catchment). Geologically, the study area belongs to the Ortler-Campo-Cristalin (Mair *et al.*, 2007). Permafrost and rock glaciers are most probably present in this region at elevations higher than 2600–2800m a.s.l. (Boeckli *et al.*, 2012). Two active rock glaciers feeding two springs at 2600 m a.s.l. (0.09 km^2) were selected in the Upper Sulden in 2015 and one rock glacier at 2718 m a.s.l. (0.08 km^2) were chosen in the Upper Zay catchment in 2017, an eastern sub-catchment within the main Sulden stream Valley. Meteorological data were measured by an Automatic Weather Station at 2825 m a.s.l. of the Hydrographic Office (Autonomous Province of Bozen-Bolzano).

Water sampling

Initially, we carried out a monthly sampling of two springs and one stream station as reference draining the rock glaciers in the Upper Sulden catchment from July to October 2015 (Engel *et al.*, 2017a). We resumed the study from June to September 2017 and added the two springs and one stream stations in the Zay sub-catchment. In addition, we sampled potential runoff components such as snowmelt, glacier melt, and precipitation. While all types of melt waters were sampled as grab samples of dripping meltwater from snow patches and the glacier surface, precipitation was

taken from bulk collectors placed in proximity to the rock glaciers.

Water analysis

Electrical conductivity and water temperature were measured by a portable conductivity meter WTW 3410 (WTW GmbH, Germany) with a precision of +/- 0.1 µS cm^{-1} (nonlinearly corrected by temperature compensation at 25 °C). Isotopic analysis was conducted by laser spectroscopy (L2130-i, Picarro Inc., USA) at the Free University of Bozen-Bolzano. Major, minor, and trace elements were analyzed by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS ICAP-Q, Thermo Fischer) at EcoResearch l.t.d. (Bozen).

Results

Tracer-based melt water characterization

Results from 2015 show that water from the two springs and the stream in the Upper Sulden catchment fell along the global meteoric water line, indicating Atlantic water vapour as water source. Melt water from rock glaciers showed typical ice melt isotopic signatures (δ^2H: -91 to -105‰) and relatively high EC (380 to 611µS cm^{-1}). Preliminary results indicate that EC, Sr, As and K concentration could be used to discriminate rock glacier melt waters from stream waters for the Sulden sub-catchments in 2015. The important role of EC, Sr, and As as indicators was confirmed in 2017 for spring waters from both sub-catchments. Notably, As concentrations exceeded thresholds for drinking water both in the Sulden and Zay springs from summer to autumn.

Conclusions

The multi-tracer approach based on stable water isotopes, EC, and major, minor, and trace elements proved to be useful to initially characterize rock glacier melt waters in the study area. While isotopic data revealed that all different water types in the catchment derived from Atlantic origin, some hydrochemical parameters (EC, Sr, and As) showed distinct characteristics when comparing rock glacier fed-spring water and reference stream waters (i.e. not fed by permafrost). Similarly, these element concentrations also characterized high-elevation spring water in the Matsch Valley, a neighbouring valley of the study area (Engel *et al.*, 2017b). Further work is needed to fully elaborate the tracer dataset obtained and to carry out additional water sampling during the following years, corroborating the present findings.

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