Rock glacier outflows: a distinct alpine stream type?

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Abstract

Alpine glaciers are predicted to significantly decrease their water contribution to European Alps ecohydrology, while rock glaciers may become increasingly important due to their slower ice loss. Different alpine stream habitat types can be distinguished according to water source. However, despite the large amount of literature available for glacier-, groundwater- and snowmelt/precipitation-fed habitats, very little is known on rockglacier-fed streams. We describe the habitat parameters of two rockglacier outflows during summer 2017, compared to streams with different water origin (two groundwater-fed, two glacier-fed, one mixed origin) in the upper Solda Valley (Eastern Italian Alps). The Solda rockglacier stream is characterized by high channel stability, low turbidity, high electrical conductivities and high Ca, Mg, PO_4, Sr, As and Ba concentrations. The water chemistry of the Zay rock-glacial stream resembles the stream of mixed origin. Results suggest a potential hydroecological role of rockglacier-fed streams in the context of Alpine deglaciation.

Keywords: Deglaciation, rock glacial streams, Alpine hydroecology, habitat conditions

Introduction

Rockglaciers are one of the most evident forms of permafrost in mountain areas such as in the European Alps, where they often feed streams or lakes (e.g Mair et al., 2015). Since deglaciation proceeds at quicker rates for glaciers than for permafrost (Haeberli et al., 2016), valley glaciers are expected to lose their key role of hydrological drivers in Alpine catchments over the next decades. Rock glacier outflows might become increasingly important in deglaciating Alpine areas, especially in the forecasted enhanced precipitation stochasticity (Milner et al., 2009) and earlier summer snowmelt (Stewart, 2009). Water origin is fundamental for shaping the hydroecology of Alpine streams, since it determines the geomorphological, physical and chemical conditions that influence biotic communities (Ward, 1994; Brown et al., 2003). Even if little studied so far, rockglacier-fed streams are characterized by distinctive habitat conditions (Mair et al., 2015; Colombo et al., 2017), and thus they can potentially host peculiar biotic communities.

Research aims and methods

This study aims at identifying key habitat characteristics of rock glacial streams. The study area is located in the Solda valley (Ortles-Cevedale massif, Italian Alps), with sampling stataions in the upper Solda and Zay subcatchments (2105-2833 m a.s.l.) draining metamorphic gneiss bedrocks (Province of Bolzano, 2017). We compared the physical and chemical features (Table 1) of 7 streams with different water source (2 fed by rockglacier, 2 by groundwater, 2 by glacier, 1 with mixed source), sampled in June, August, and September 2017. Water origin was verified by analyzing δ^2H and $\delta^{18}O$ in stream waters using mixing models with snowmelt, precipitation, and glacier ice melt as potential end-members.

A Principal Component Analysis (PCA) was applied to the environmental variables of all samples collected in summer 2017. The same method was applied only to trace elements.

Table 1. List of habitat features and corresponding physico-chemical variables used in the analysis.

Habitat feature	Variables
Water origin	δ^2H, $\delta^{18}O$ stable isotopes
Channel instability	Pfankuch index (Bottom component)
Physical parameters	Turbidity, Temperature

Anions and cations	Electrical conductivity, Ca, Mg, SO_4, SiO_2
Nutrients	NO_3, PO_4, DOC
Trace elements	Al, As, Ba, Pb, Cd, Fe, Mn, Sr, U, Zn

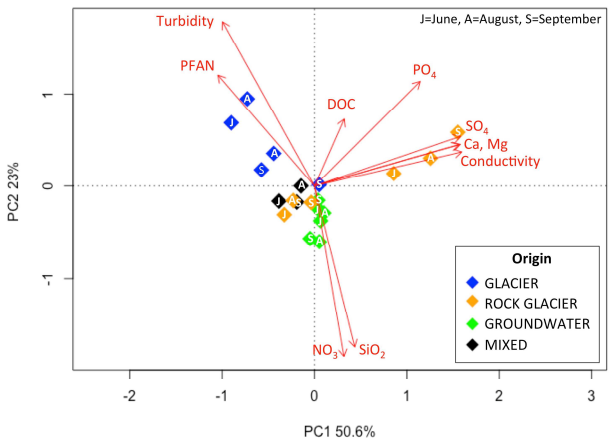
Temperature profiles along with results for trace elements, and δ^2H and $\delta^{18}O$ isotopes, currently under analysis, will be shown in the presentation.

Results and discussion

Temperature profiles (measured with dataloggers) showed only very small diel oscillations for both rock glacial streams, compared to the other stream types.

The Solda rock glacial stream (SRG) was separated from all the other stations (Fig. 1) based on its clear waters (NTU<3), low temperatures (<1.2°C), stable channel (PFAN=19), higher electrical conductivity (376-630 µS cm^{-1}) and Ca (47.5-73.5 mg L^{-1}), Mg (12.5-15 mg L^{-1}), PO_4 (3.8-5 µg L^{-1}) and SO_4 (107.3-170 mg L^{-1}) concentrations, which increased over summer. The Zay rock glacial stream (ZRG) resembles the mixed origin station (Fig. 1). This is likely due to the infiltration of glacial waters into the upstream rock glacier margin (personal observation), thus smoothing the permafrost signal. Glacier-fed streams are characterized by high seasonality, with higher turbidity (NTU=43-132) and lower conductivity (EC=9-72 µS cm^{-1}) in June and August than in September (EC=79-270 µS cm^{-1}, NTU=32-60), when flow was almost exclusively subglacial, due to the low air temperatures.

Figure 1. PCA biplot of habitat variables of the streams sampled in summer 2017.



Conclusions

Our results show that rockglacial streams, in agreement with information in literature, represent peculiar habitats, according to a set of physical and chemical parameters. However, the similarity of Zay rock glacial stream with non glacial streams underscores that hydrological complexity must be taken in consideration when assessing the hydroecological peculiarity of rock glacier fed headwaters.

These results confirm that rockglacier fed streams deserve more attention in relations to effects of global warming on Alpine hydrology.

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