The project “ROCK-ME: Geochemical response of Alpine Rock Glaciers to global warming: hydroecological consequences of trace element Export”

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- 3 partners, one for each Europaregion partner: Trentino, and South Tyrol in Italy, Tyrol in Austria

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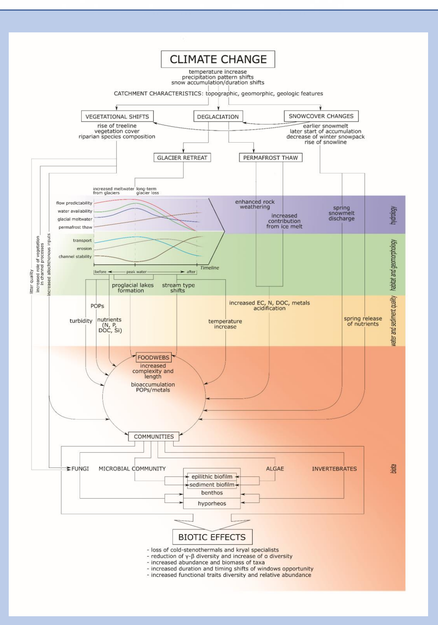
OVERVIEW



Conceptual model of the effects of climate change (CC) and deglaciation on Alpine stream ecosystems. Lines with arrows: direct influence. CC interacts with catchment specific features in determining deglaciation and shifts in snow cover and vegetation. These key catchment changes and their interactions have distinct consequences on the hydrology, geomorphology and habitat, and on the quality of water and sediment. Different time scale impacts of glacier retreat show the trend of key hydrological and geomorphological parameters over the two identified phases, i.e. before and after the “peak water” period governed by glaciers. The resulting key biotic effects of deglaciation on Alpine streams are summarized in bullet points. From Brighenti at al., 2019, STOTEN, https://doi.org/10.1016/j.scitotenv.2019.04.221

Rock glaciers (i.e., creeping rocky debris containing permafrost ice) are the most widespread form of Alpine mountain permafrost, and their internal ice represents an important water reservoir globally. Rock glaciers strongly influenced the habitat template of downstream waters due to high solute export, especially in late summer under increased permafrost thaw. Rock glaciers may become increasingly important in shaping the hydroecology of alpine river systems under continued deglaciation.

GOALS OF THE PROJECT

- Estimate the origin, the export and the ecological effects of trace elements in river networks affected by rock glacier thawing and glacier retreat
- Predict the future shifts of Alpine streams hydroecology under climate change

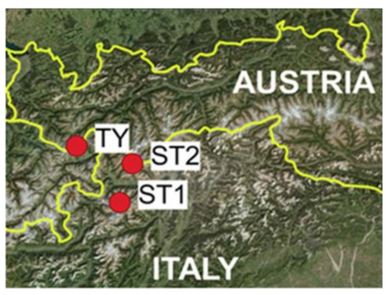
RESEARCH HYPOTHESES

- In the short-term, trace elements reach peak concentrations either during the snowmelt (due to present-day deposited chemicals), autumn (due to legacy contaminants) or autumn-winter (due to weathering products);
- In the long-term, the combined effect of permafrost thaw and glacier retreat will cause the bulk concentrations of trace elements in the Alpine river networks to increase, with the peak associated with permafrost thaw;
- Most trace elements found in surface waters originate from bedrock weathering, and a smaller amount derives from present and past atmospheric deposition;
- Present-day deposition results in major concentrations occurring during the snowmelt period in all stream sections. Legacy contaminants are released during the glacier ablation or permafrost thaw periods;
- Trace element enrichment determines biomagnification processes in the aquatic foodweb, absence of sensitive species in dwelling communities of microbes, diatoms and invertebrates, and sub-lethal effects responsible for deformities in the body growth (diatoms, invertebrates);
- Microbial metabolism can enhance or damp the bioavailability and toxicity of trace elements;
- Metal resistance genes among bacterial communities are more frequently expressed in waters affected by thawing rock glaciers, and some are associated with resistance to antibiotics;
- We expect unknown resistance genes or novel variants to be released by thawing rock glaciers, as their ice hosts ancient water.

STUDY AREA

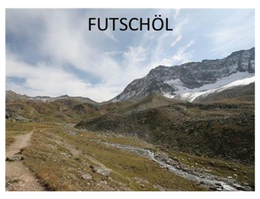
WHERE? Study area

- Futschöl Valley (Jamtal, Upper Paznaun, Tyrol, TY)
- Madritsch/Madriccio (Martelltal/Val Martello, South Tyrol, ST1)
- Lazaun (Schnalstal/Val Senales, South Tyrol, ST2)



The three study areas represent different stages of deglaciation:

- Futschöl: still highly-glacierized, several rock glaciers
- Lazaun: residual glaciers (after the peak water), several rock glaciers
- Madritsch: no glaciers, residual ice fields, several rock glaciers



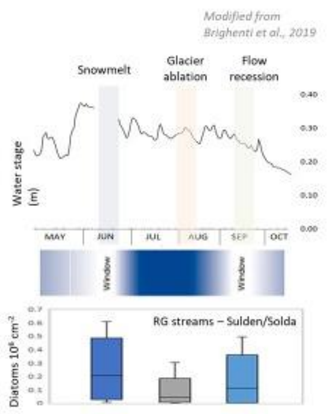
WHEN?

Key periods in summer, max. and min biological development:

1. between snowmelt and ice melting
2. glacier ablation
3. recession (base flow)

Additional periods (weather conditions), e.g.

- autumn (dry, before first frost and snow)
- winter (effect of snow cover)



HOW? Sampling and monitoring stations

Five stream locations intensively monitored for each subcatchment:

- Intact rock glacier
- Relict rock glacier
- Glacier
- Reference spring (draining an area without periglacial landforms/glaciers/permafrost)
- Subcatchment outlet

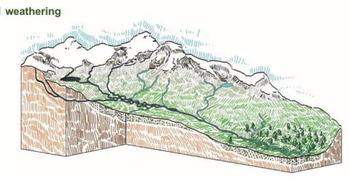
METHODS: YDROLOGY AND HYDROGEOCHEMISTRY

Field and monitoring data
- Continuous hydrological monitoring
- Water origin and water chemistry

→ Water budget estimation, Chemical mass balances → **FUTURE SCENARIOS**

WHAT?

Snowmelt
Glacier ice melt
Rainfall
Weathering
Periglacial weathering → WATER AND SOLUTES



HOW?

- Gauging stations (intact/relict rock glacier, glacier, non-glacial spring, outlet)
- Biweekly collection of water samples of streams and their water sources

Gauging · Stream water · Water sources

METHODS: GEOLOGY

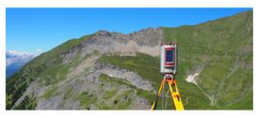
Collection and analysis of existing data → To decide in which task to put most effort, and which data already exists

Geological and geomorphological characterization → To specify the characteristics and landforms of the 3 sites

Processes

WHAT?

- in-situ geomorphological and geological mapping with special attention on permafrost tackled by ground and water temperature measurements and GPR surveys;
- Geological characterization of watersheds: tectonic, petrographic, geochemical and grain-size analyses of the RG active layer.



HOW?

- Field, remote sensing, laboratory

METHODS: ECOLOGY

Benthos

WHAT?

Focus on benthic communities in streams fed by different water types

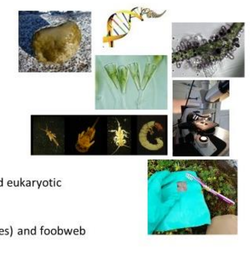
Epilithic biofilm (prokaryotes, diatoms)
Epipsammic biofilm (prokaryotes in stream sediments)
Epiphytic biofilm (diatoms) and macrozoobenthos
Benthic habitat (macrozoobenthos)

Supporting data:

Water: DOC, SS, nutrients, trace elements

Biofilm: organic content, chlorophyll *a* (as a proxy of all pro- and eukaryotic photosynthetic organisms)

Interaction with metagenomic (metabolic paths, resistance genes) and foobweb analyses and Hydrological-hydrochemical monitoring



HOW?

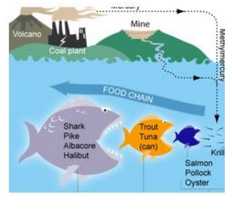
- determination of organic content in water and biofilm
- Metabarcoding of biofilm prokaryotes (sampling + analyses)
- Benthic chlorophyll *a* and periphytic diatoms
- Macrozoobenthos
- Metagenomics of spring biofilms (co-ocurrence of metal resistance with antibiotic resistance)

Foodwebs

WHAT

Food web analyses, trace element uptake and bioaccumulation

The characterisation of stream foodwebs with Carbon and Nitrogen stable isotopes will be used to reconstruct possible pathways of **uptake/biomagnification of trace elements** in biofilms, bryophytes, and benthic invertebrates



HOW?

- Foodweb analysis based on δ13C and δ15N isotopic ratios in different matrices:
  - FPOM (= fine detritus),
  - epilithic biofilms
  - bryophytes
  - benthic invertebrates (different taxa, characterized based on their trophic role)
  - Riparian vegetation
  - *Hydrurus foetidus*

Alpine streams foodweb are simplified