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Alpine headwaters emerging from glaciers and rock glaciers host different bacterial communities: ecological implications for the future

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Alpine glaciers are predicted to vanish within the next few decades due to the global warming. As the thawing rate of mountain permafrost ice is much lower than for glacier ice, a shift from glacial to periglacial dynamics is predicted for Alpine headwaters during the 21st century. However, knowledge on chemistry and biology of water emerging from Alpine rock glaciers (i.e. permafrost landforms composed by mixed ice and debris) is still sparse. We present the results from an investigation of glacier-, rock glacier- and groundwater/precipitation-fed streams of the Italian Central Alps aimed at exploring bacterial community composition and diversity in epilithic and surface sediment biofilm. Rock glacier-fed waters showed high solute concentrations related to bedrock lithology, and their highly diverse bacterial assemblages significantly differed from those detected in glacier-fed streams. Bacterial taxonomic composition appeared as mainly related to water and substrate type, as well as to water chemistry, in particular to concentrations of nutrients and trace metals. This study supports the hypothesis that rock glacier-fed headwaters represent chemically and biologically peculiar ecosystems able to act as *ecological refugia* for cold stenotherm taxa, and suggests a potential driving role of thawing permafrost in modulating future ecological traits of Alpine headwaters.