**The negative effects of environmental radioactivity on microbial communities inhabiting the surface of glaciers**

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Environmental radioactivity have two sources, natural and anthropogenic. Studies testing the direct influence of natural radioactivity were mainly conducted in areas with elevated background radioactivity, such as the Ramsar area (Iran). While, the effects of anthropogenic radioactivity on biota are strongly limited to nuclear power plant accidents and former nuclear weapons test sites. The last decades of research have revealed that biotic sediment on the surface of glaciers worldwide, called cryoconite, effectively accumulates natural and anthropogenic radioisotopes originated from the atmospheric deposition. Due to simple trophic networks and truncated trophic structure, low temperatures, and elevated radioactivity, glaciers are good systems for testing radioisotopes-organisms interactions, both in terms of accumulation and negative effects of ionizing radiation (IR) on organisms.

Our study was conducted on the glaciers in the Alps. The first step assessed the factors on a glacial and interglacial scale that affect the accumulation of the main natural (210Pb), and anthropogenic radioisotopes (137Cs, 239+240Pu, 241Am) and their potential fate. This allowed us to understand the relationship between organisms and radioisotopes, primary microbial communities, which are crucial for glaciers and glacier-adjacent ecosystems functioning. The second part of the study tested the negative effect of natural and anthropogenic radioactivity on the biodiversity of bacterial and micro-eukaryotic assemblages, and the abundance of genes annotated to pathways related to DNA-repairing systems. Finally, to understand the cause-and-effect of the former relationship, we conducted a laboratory experiment testing the effect of elevated IR on oxidative and DNA-repairing systems activity based on differential gene expression using RNA-seq.

Analysis based on 20 glaciers sampled across the Alps revealed a high variation in mean activity concentrations of both natural and anthropogenic radioisotopes, ranging 36 Bq kg-1 to 5785 Bq kg-1 for 137Cs and from 1013 Bq kg-1 to 10 711 Bq kg-1 for 210Pb. This strong variation was also observed between samples on the same glacier. This intra-glacial variation is related to the organic matter content and chlorophyll concentration of the sediment. The inter-glacial variation is primarily related to the organic matter content of the sediment, with no effect of past precipitation. The richness of bacterial strains was negatively related to the total measured activity concentration between glaciers, with no effect of the 210Pb/137Cs ratio. The negative effects of IR on the biodiversity of micro-eukaryotes were stronger when the total share of 210Pb was higher. This difference was explained by the differential accumulation of these radionuclides in cryoconite: 210Pb is more strongly bound to developing communities, while 137Cs is mainly bound to minerals. Moreover, glaciers with higher activity concentrations of 137Cs and 210Pb are inhabited by bacterial strains with a higher abundance of genes related to DNA-repairing systems, as a potential adaptation for living in an environment with elevated radioactivity. As these organisms are often endemic species, global warming along with elevated radioactivity could threaten glacial biodiversity.