Geophysical Research Abstracts
Vol. 21, EGU2019-1616, 2019
EGU General Assembly 2019

The Secrets of Black Holes on Ice: Eco-physiology of Microorganisms in Cryoconite Holes

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Although often seen as isolated and pristine, polar regions are connected with the other biomes by long-range transport via atmosphere. Bacteria transported from remote areas with snow and dust particles are deposited on the glacial surfaces, where some of them find habitable niches. An example of such niches are cryoconite holes, regarded as hotspots of microbial processes on glacier surfaces. It is commonly known that these holes affect the albedo and biogeochemical cycling on glaciers. Data on how microorganisms function in cryoconite holes and details on biogeochemical interactions within the holes are, however, scarce.

We applied a range of microbiological and molecular biology tests to understand the eco-physiological capabilities of the most abundant cultivable microorganisms from cryoconite holes worldwide (Greenland, Svalbard, Antarctica). Oxic and anoxic conditions were applied to mimic microniches within the habitat. The growth of bacteria was assessed under a range of treatments: freeze-thaw cycles, temperature gradients, extreme pH and salinity conditions and varying organic carbon substrates. Bacterial cultures were identified by 16S rRNA genes and compared to the genomic data of community structures (Illumina sequencing) from the selected holes.

Our study demonstrates that heterotrophs of cryoconite holes are adapted to fast - changing environmental conditions by ability to survive multiple freeze-thaw cycles and changing oxygen conditions, and scavenging a wide range of organic substrates. Furthermore, these microorganisms thrive in conditions outside of environmental ranges found in the holes (extreme pH and salinity values). We discuss their potential to thrive in the future melt scenarios as well as influence downstream environments with increased glacial melt.