The nitrogen cycle in cryoconites: naturally occurring nitrification-denitrification granules on a glacier

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Microbes occasionally form granular structures in both natural and artificial environments. Cryoconite granules are naturally occurring spherical structures, with a diameter ranging from 0.2–2 mm, which are frequently found on the surface of glaciers. Cryoconites have a significant influence of glacier mass balance because the granules decrease surface albedo, ratio of reflected flux to incoming flux of solar radiation, and accelerate the melting of snow and ice.

While it has been postulated that the microbes in cryoconite granules play an important role in glacier ecosystems, information on their community structure is still limited and their functions remain unclear. Here, we present evidence for the occurrence of nitrogen cycling in cryoconite granules on a glacier in Central Asia. We detected marker genes for nitrogen fixation, nitrification, and denitrification in cryoconite granules by digital PCR, while digital RT-PCR analysis revealed that only marker genes for nitrification and denitrification were abundantly transcribed. Analysis of isotope ratios also indicated the occurrence of nitrification; nitrate in the meltwater on the glacier surface was of biological origin, while nitrate in the snow was of atmospheric origin. The predominant nitrifiers on this glacier belonged to the order Nitrosomonadales, as suggested by amoA sequences and 16S rRNA pyrosequencing analysis. Our results suggest that the intense carbon and nitrogen cycles by nitrifiers, denitrifiers, and cyanobacteria support abundant and active microbes on the Asian glacier.