Are Perchlorate Brines Habitable?

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Abstract

Natural occurring perchlorate deposits are rare on Earth because these salts are highly soluble and, thus, easily leached into the groundwater where they are decomposed by perchlorate-reducing microorganisms (Bardiya and Bae, 2011). However, extraterrestrial hyperarid surface environments, where high levels of UV radiation can oxidize chlorides to perchlorates (Carrier and Kounaves, 2015), could result larger perchlorate reservoirs. The occurrence of perchlorates has been shown for Mars, e.g. 0.4 – 0.6 wt% perchlorate in the soil at the Phoenix landing site (Hecht *et al.*, 2009), and has been supposed for other planetary bodies like Europa (Ligier *et al.*, 2016). Although these salts are important in an astrobiological context as they are very hygroscopic and can lower the freezing point of water significantly, little is known about the habitability of perchlorate brines.
In our recent experiments we determined the maximum perchlorate concentrations suitable for growth of various halophilic organisms. For example, we found a perchlorate tolerance of 12 wt% (1.1 M) NaClO4 for the halotolerant bacterial strain *Planococcus halocryophilus,* which is the highest tolerance to perchlorate reported to date (Heinz *et al.*, 2018; 2019). Experiments with other strains are ongoing. Macroscopic and microscopic observations have shown that perchlorate-specific stress responses can occur during growth of *P. halocryophilus* at high perchlorate concentrations. Cells growing under these conditions form large cell clusters, and cell colonies grown on agar plates develop different macroscopic phenotypes compared to cells grown in perchlorate-free medium (Heinz *et al.*, 2019).

The results of these experiments suggest that a microbial adaption to perchlorates, in an environment where these salts occur naturally in high quantities, might be possible to the same extent as halophilic organisms on Earth have been adapting to NaCl-rich habitats, e.g. in the Atacama Desert, Chile (Davila and Schulze-Makuch, 2016). Thus, highly concentrated perchlorate brines on Mars or in other extraterrestrial environments might not be habitable to any organism known on Earth, but microorganisms appear to be able to evolve thriving in such environments.

References:

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