Challenging the survival potential of a desiccation-, radiation-tolerant cyanobacterium with perchlorates: Implication for the habitability of Mars

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Abstract

The discovery on the Martian surface of perchlorate at the levels of 0.4-0.6 wt% has profound implications for the habitability of this planet (Hassler et al. 2013). In order to further investigate the effects of this highly oxidizing agent on microbial survival we exposed a model astrobiological organism, the desiccation-, radiation-tolerant cyanobacterium *Chroococcidiopsis* sp. CCMEE 029 (Billi 2018), to different perchlorate concentrations. Although this cyanobacterium has been shown to be highly resistant to space and Mars-like conditions (Billi et al. 2019a; Billi et al. 2019b), its capability to cope with perchlorate salts remains unexplored. Therefore in order to investigate the effects of perchlorate on the survival limit and adaptation potential of this extreme-tolerant microorganism, *Chroococcidiopsis* cells were grown in BG-11 liquid medium supplemented with 5 mM, 50 mM and 100 mM Mg(ClO4-)2, NaClO4- and Ca(ClO4-), as well as with 2.4 mM perchlorate as reported by NASA's lander Phoenix (Hassler et al. 2013). The effects of such a highly oxidizing environment on the cyanobacterial growth and morphology were evaluated by monitoring cell densities over one-month period and by staining treated cells with molecular probes (Billi 2009).
Results revealed that perchlorate concentrations up 50 mM did not alter the growth or the morphology of *Chroococcidiopsis* sp. CCMEE 029, thus providing relevant information for future experiments under Mars-like conditions to be performed by using ground-based simulations or space facilities either available outside the International Space Station or future ones on the Moon's surface or orbiting around it, e.g. the Gateway.

Furthermore, cell lysates obtained from *Chroococcidiopsis* cells grown in the presence of 2.4 mM perchlorate were successfully used to support the growth of the heterotrophic bacterium *Escherichia coli*, thus providing a first milestone in the development of a biological life support system based on *in situ* resource utilization by means of a cyanobacterium-based technology (Billi et al 2013; Verseux et al. 2016).

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References

Billi, D. (2009) Subcellular integrities in *Chroococcidiopsis* sp. CCMEE 029 survivors after prolonged desiccation revealed by molecular probes and genome stability assays. *Extremophiles*13(1), 49-57

Billi, D. (2018) Desert cyanobacteria under space and planetary simulations: a tool for searching for life beyond Earth and supporting human space exploration. *International Journal of Astrobiology* 1-7

Billi D, Baqué M, Smith D.H. and McKay C.P. (2013) Cyanobacteria from extreme deserts to space. *Advances in Microbiology* 3(6), 80-86

Billi, D., Verseux, C, Fagliarone, C., Napoli, A., Baqué, M. and de Vera J.-P. (2019a) A desert cyanobacterium under simulated Mars-like conditions in low Earth orbit: Implications for the habitability of Mars. *Astrobiology* 19(2), 158-169.

Billi, D., Staibano, C., Verseux, C.,Fagliarone, C., Mosca, C., Baqué, M., Rabbow, E. and P., Rettberg (2019b) Dried biofilms of desert strains of *Chroococcidiopsis* survived prolonged exposure to space and Mars-like conditions in low Earth orbit. *Astrobiology* [Feb 11, Epub ahead of print].

Hassler, D.M., Zeitlin, C., Wimmer-Schweingruber, R.F., Ehresmann, B., Rafkin, S., Eigenbrode, J.L., Brinza, D.E., ... and MSL Science Team (2013) Mars' surface radiation environment measured with the Mars Science Laboratory's Curiosity rover. *Science* 343(6169), 1244797.

Verseux, C., Baqué, M., Lehto, K., de Vera J.-P., Rothschild, L.J. and Billi D. (2016) Sustainable life support on Mars - the potential roles of cyanobacteria. *International Journal of Astrobiology* 15, 65-92.