Astrobiological Studies on Halophilic Psychrophiles Isolated from High Altitude cold region of North of Pakistan

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1. Introduction
As halophiles tolerate so many forms of environmental stress, they are 'exophiles'- organisms that might survive on Mars or other planets. They might also be capable of surviving journey between planetary or celestial bodies - embedded in salt crystals that protect them from damaging radiations. The Shergotty and Nakhla meteorites from Mars, contain halite salt crystals, which could carry halophilic organisms and transport to other planets. The indications of presence of a brine ocean beneath the ice of Europa suggests that it constitutes of hydrated minerals [1] but it is not clear yet, if these are sulphate salts, acid or alkaline. The infrared spectroscopy by the Galileo spacecraft has indicated the possible presence of hydrated salts, with mixtures of epsomite ($MgSO_4.7H_2O$), bloedite ($MgSO_4.Na_2SO_4.4H_2O$), mirabilite ($Na_2SO_4.10H_2O$) and natron ($Na_2CO_3.10H_2O$) [4]. The ocean of Europa may also be salty, and could contain NaCl [2].

2. Aim of the study
In order to assess the possible ability to survive in space ecosystem, bacterial and archaeal isolates from glaciers and high altitude cold lake, were exposed to extreme conditions of temperature, UV radiation, high concentration of NaCl and other salts.

3. Methodology & Findings
The bacterial and archaeal isolates DBA1 (*Halorubrum chaoviator*), BSA (*Halostagnicola* spp.), KK4 (*Chomohalobacter salexigens*), HTP-9 (*Pseudoalteromonas haloplanktis*), HTP-11(*Psychrobacter cryohalolentis*), HTS-4(*Janthinobacterium lividium*) and HTS-27 (*Arthrobacter citreus*) were from from hypersaline regions and Borith Lake, Passu, Siachen glaciers in HKKH region (Hindukush, Karakoram Himalaya). Strains HTP-9, HTP-11, HTS-4, HTS-27 showed growth at 5-20°C. The strains HTP-9, HTS-4, and HTS-27 were able to survive at NaCl concentration up to 26%, and HTP-11 was able to tolerate up to 36% NaCl. Only DBA1, HTP-9, and HTP-11 were able to survive at different concentrations of $MgSO_4$, $CaCl_2$, Na_2HPO_4, and KNO_3. However, BSA, HTP-9, HTP-11 and HTS-4 were able to survive at increased concentration of $KClO_4$. The growth of strains DBA1, KK4 and BSA was observed up to 45°C. Strain DBA1 demonstrated higher percentage survival at 700 Jm^{-2} while HTP-11 showed least percentage survival at 700 Jm^{-2}

4. Conclusion & Future Prospects
This study highlights the characteristics of microbes that can adapt to extreme conditions of space or planetary bodies with high salt concentrations and resist UV. Behavior of these microbes shows promising astrobiological implications in future.

5. References
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Short Summary
Bacteria and archaea from glaciers and cold brine lake in Pakistan were exposed to extreme temperature, UV radiation, high concentration of NaCl and other salts. They showed growth at 5-20°C, survived 26% and 36% of NaCl, 37 different concentrations of $MgSO_4$, $CaCl_2$, Na_2HPO_4, and KNO_3, and increased concentrations of $KClO_4$ also demonstrated higher percentage survival at 700 Jm^{-2}.