

The contamination impact of human exploration to a subterranean environment and the implications for further crewed space exploration

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The quest of exploring and looking for life in new places is a human desire since centuries. Nowadays, we are not only looking on planet Earth any more, but our endeavours focus on nearby planets in our solar system. It is therefore of great importance to preserve the extra-terrestrial environment and not to contaminate it with terrestrial / human associated bacteria. At this point in time we are not able to send crewed missions to other planets; however, analysing the impact of human exploration on environments is of great planetary protection concern. This can be achieved by obtaining samples from a subterranean environment, where only expert speleologists have access and the human impact is considered very low. For this study, astronauts participating in the 2014 ESA CAVES (Cooperative Adventure for Valuing and Exercising human behaviour and performance Skills) training course, obtained samples from deep within a subterranean environment and returned them to the laboratory for molecular microbial analysis.

The diversity of the returned soil samples was analysed by next-generation sequencing (NGS). It was found that humans can have an immense impact on the microbial diversity in the environment. Although the cave system is sparsely entered by humans, a high relative abundance of *Staphylococcus* spp. and *Propionibacteria* spp., organisms that are characteristic for human skin, have been recovered in some places. Some samples even showed the presence of human gut associated methanogenic archaea, *Methanomassiliicoccus* spp. The obtained data from this investigation indicates that human exploration is polluting an environment and may lead to false-positive sign of life on other planets. It is therefore imperative to increase our awareness to this problem as well as work towards new protocols to protect a pristine extraterrestrial environment during exploration.