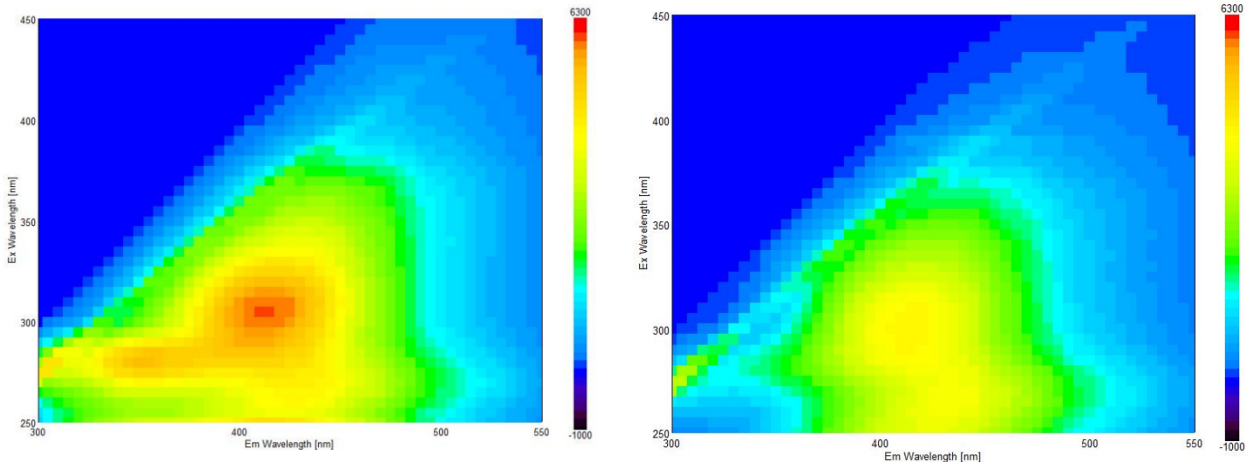

Fig.1: Fluorescence excitation/emission matrix of lignite-derived LHS (a) and soil-derived SHS (b) humic substances.

Strong fluorophores (excitation/emission) are detected at 270/445nm. Eight general categories of fluorescence peaks were postulated by P.G. Coble [10], including pigment-like, protein-like, and humic-like fluorescence signatures. The maximal peaks observed in the current investigation are located in the area designated as "A peak," which corresponds to the humic-like substances. The dispersion of the LHS peak within the wavelength range of 275/440–450 nm was likely attributable to their heterogeneous composition. Due to the evident similarity between the EEMs of LHS and SHS, all peaks are classified as humic-like. Nevertheless, the marginal fluctuations in peak positions that were noted suggest subtle variations in the composition of humic substances among the samples. This shows that LHS possesses aromatic structures consisting of three to four rings. The findings indicate that humic substances derived from different sources can be properly characterized using EEM spectroscopy, which is important as the process of drug development utilizing humic substances entails the examination of their various chemical and pharmacological characteristics and establishing standards.

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AstroBioLab: Review of Technical and Bioanalytical Approaches

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Abstract –This study presents the concept of AstroBioLab, an autonomous astrobiological field laboratory tailored for the exploration of (sub)glacial habitats. AstroBioLab is an integral component of the TRIPLE (Technologies for Rapid Ice Penetration and subglacial Lake Exploration) DLR-funded project, aimed at advancing astrobiology research through the development and deployment of innovative technologies. AstroBioLab integrates diverse measurement techniques such as fluorescence microscopy, DNA sequencing and fluorescence spectrometry, while leveraging microfluidics for efficient sample delivery and preparation.

AstroBioLab is designed as an instrument for approaching fundamental questions regarding the existence and adaptability of life in extreme environments, with Antarctica serving as a terrestrial analogue to extraterrestrial habitats. Its integration into the TRIPLE project should facilitate the investigation of Antarctic ecosystems, shedding light on the limits and adaptations of life under extreme conditions.

Through its autonomous operation, AstroBioLab should minimize human intervention, optimize efficiency and reduce contamination risks. State-of-the-art automation systems and advanced artificial intelligence algorithms should enable automated sample handling and analysis. This approach ensures the integrity of pristine environments and streamlines data acquisition.

To comprehensively assess the collected environmental samples, AstroBioLab will employ a suite of measurement techniques. Fluorescence microscopy enables the visualization and identification of microbial life, providing valuable morphological insights. DNA sequencing elucidates the genetic diversity and phylogenetic relationships of the detected microorganisms, enhancing our understanding of their evolutionary origins and adaptation strategies. Furthermore, fluorescence spectrometry assists in identification and quantification of specific biomarkers, thus offering valuable information about the biochemical processes within the samples.

Sample delivery and preparation will be performed using microfluidics-based systems. Due to precise fluid control and manipulation, microfluidics technology enables efficient handling of small sample volumes and reagents. This allows rapid and accurate sample processing, minimizes contamination and facilitates high-throughput functioning.

The integration of AstroBioLab into the TRIPLE project represents a significant advancement in the exploration of extreme environments and in the search for extraterrestrial life. By combining autonomous operation, synergy in measurement techniques and microfluidic-based sample handling, AstroBioLab provides a powerful platform for studying and characterizing microbial life in Antarctica. The findings from this project should contribute to our understanding of the potential habitability of other celestial bodies and promote future astrobiological explorations.