High hydrostatic pressure as a modulator of microplastic–microbiome interactions: a deep-sea analogue approach

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Abstract

Microplastics (MPs) are now ubiquitous in the deep ocean, yet their fate and their interactions with deep-sea microbial communities remain poorly understood. Under the high hydrostatic pressures prevailing below 1000 m, both microbial physiology and polymer surface properties may be profoundly altered, with potential consequences for MP colonization, biodegradation, and additive release. The PLASTIS project addresses these questions through a multi-scale experimental approach combining high-pressure milli- and microfluidic devices with molecular and physicochemical analyses.

Polystyrene microbeads (PS, 6 µm) were incubated with natural marine microbial communities at atmospheric pressure (AP, 0.1 MPa) and high pressure (HP, 10 MPa) conditions in sapphire millifluidic tubes and all-sapphire microreactors (devices that withstand pressures up to 300 bar while remaining optically transparent), enabling *in situ* monitoring by Raman spectroscopy and optical microscopy. Artificial weathering of PS beads prior to incubation induced surface cracking, as confirmed by TEM and AFM, potentially promoting microbial colonization.

16S rRNA metabarcoding revealed that hydrostatic pressure significantly restructures microbial communities associated with MPs: *Pseudomonadota* were enriched under HP conditions, while *Bacteroidota* were proportionally more abundant at AP. These trends were confirmed across two independent datasets , the latter including a range of polymer types (LDPE, polypropylene, expanded PS, bioplastic). Bioplastics incubated under HP showed distinct taxonomic profiles compared to conventional plastics, suggesting a combined effect of polymer nature and pressure on microbial community assembly.

Raman and FTIR analyses of incubated polymers further revealed surface chemical modifications under both AP and HP conditions, consistent with biotic and/or abiotic alteration processes. These physicochemical signatures complement the microbiological data and support the establishment of correlations between community structure and polymer surface state.

Together, these results demonstrate that high hydrostatic pressure is a key modulator of MP–microbiome interactions in the deep ocean, and that high-pressure sapphire microfluidic devices offer a powerful platform for their controlled investigation.

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