The influence of biofilms and mineral loading on marine plastic fate

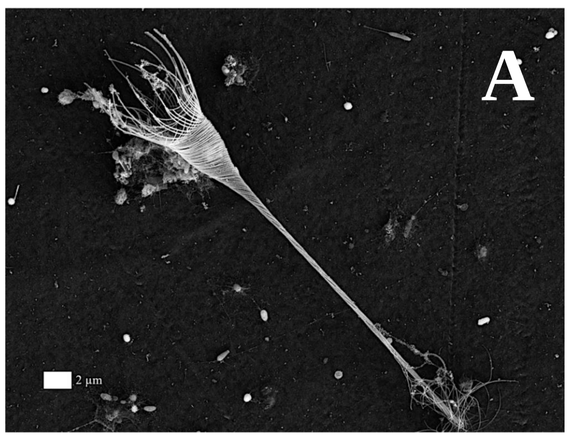
Plastic surfaces form the habitat niche known as the *Plastisphere* that influences the transport, distribution, and degradation of plastic in the marine environment. Plastic has the potential to be incorporated into biogeochemical cycles through:

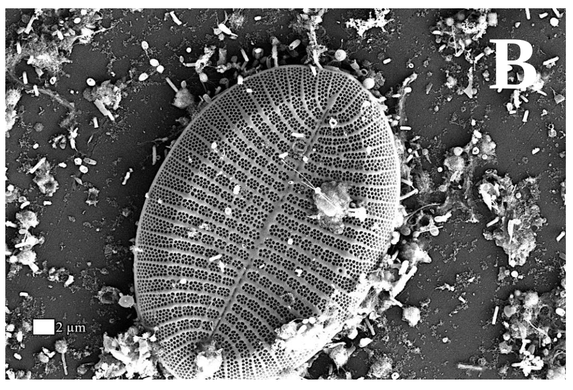
- Biological loading (the *Plastisphere* community*)*
- Mineral precipitation and transport
- Microbe-mineral interactions

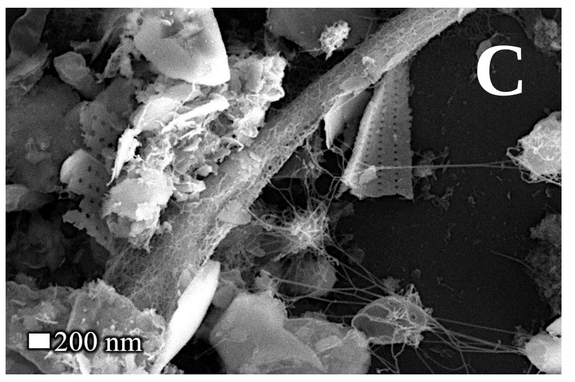
With the ever increasing amount of plastic in marine water and sediments, we must explore the mechanisms and effects of mineral precipitation on plastic´s environmental fate. Some minerals could act as a screen to protect plastics from degradation, whereas metal oxides could lead to enhanced degradation of plastic surfaces through metal catalysis.

To explore these effects we use Scanning Electron Microscopy (SEM), SEM-EDS (Energy Dispersive X-Ray spectroscopy), and He-ion microscopy to image plastics that have been exposed in an *in situ* incubation in Copenhagen, Denmark over 12 months.

Biological loading:



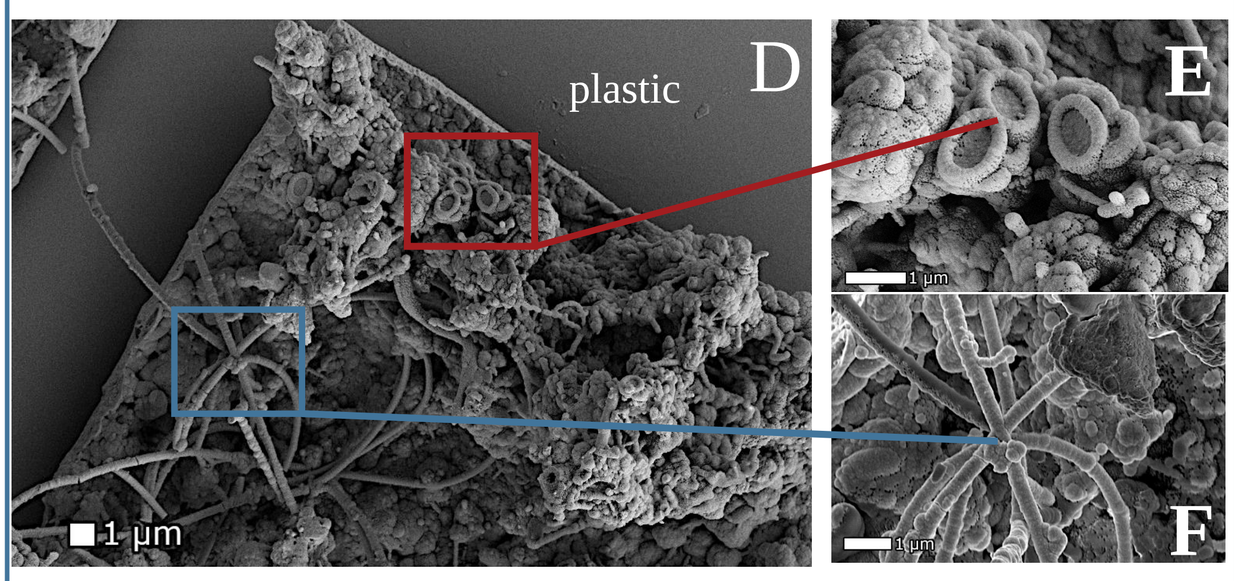




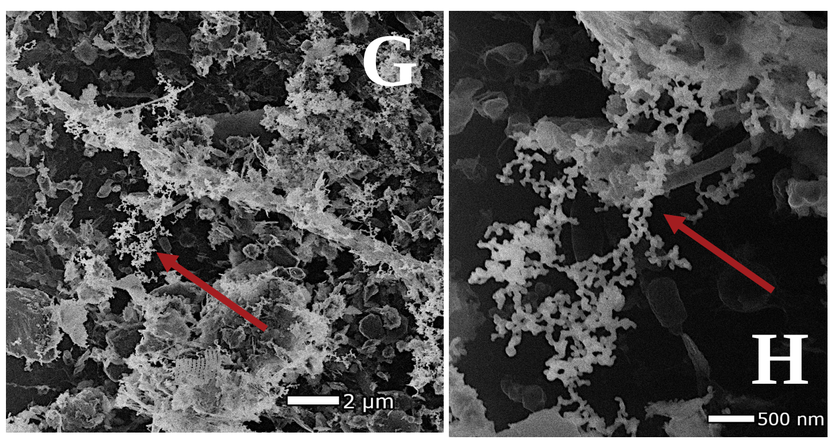
Microbes attach to the plastic surface in biofilms. Others produce mineral exoskeletons that can enhance element or nutrient export from surface waters to sediments. Once in sediments, the sticky biofilm can collect debris and other cells.
A) Choanoflagellate (Si based skeleton) attached to PE (polyethylene) exposed to the sediment water interface for 3 months.
B) Diatom attached to PS (Polystyrene) exposed 1 year to the sediment- water interface
C) Broken diatom shells, unidentified microbial cells, and exopolysaccharides attached to PS exposed to sediment water interface for 1 year.

Microbe-mineral interactions:

Some microbes excrete minerals as a product of their metabolism.



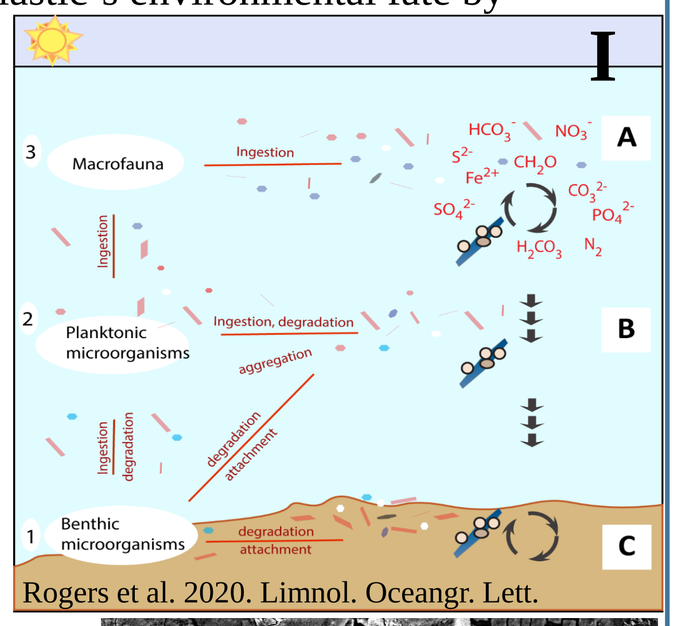
SEM images of D) biofilm developed on PS floating at the sediment water interface for 6 months. E) high diversity in biofilm F) mineralized *Lyngbya* sp., an ubiquitous autotroph in the Øresund or a sheath structure. EDS analysis on highlighted spots in E and F were enriched in Fe and Cr, possibly indicating a Fe and Cr-rich coating.



He Ion microscopy images of PE exposed to surface sediments for 10 months. Potential iron minerals secreted by iron reducing bacteria. (personal communication, S. Chiriav, MCI, NanoSyd-SDU)

Mineral precipitation & Transport:

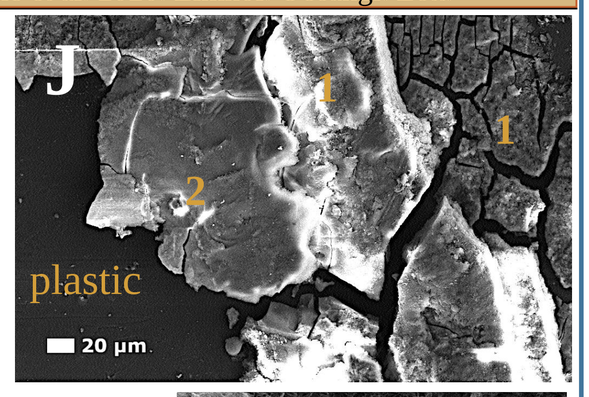
Could hydrophobicity and surface charge drive abiotic mineral precipitation on the surface of plastic as it does for initial biofilm growth? Could *Plastisphere* microbes precipitate minerals via their metabolism? Mineral precipitation may impact plastic´s environmental fate by promoting or hindering degradation and transport.

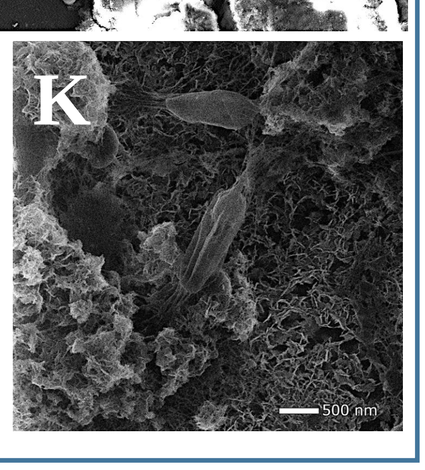


Rogers et al. 2020. Limnol. Oceangr. Lett.

I) A. While floating in the water column, biofilm develops, elements and compounds adsorb onto the surface of the plastic,
B. Which leads to changes in buoyancy causing the plastic to sink out of the water. During transport, the particles could be ingested, excreted, aggregated into flocs, continuing to develop components of the biotic and abiotic film on the surface of the plastic.
C. Once deposited in the sediment, microbial communities rework, utilize, and transform the plastic film layer
J) SEM-EDS analysis indicated that precipitates formed in layers with differing chemical compositions on PE exposed for 10 months to sediments with high concentrations of S^{2-}:

1. AlO_3, P_2O_5, some Cu_2O
2. AlO_3, P_2O_5, ZnO, Fe_2O_3





K) He-ion image of PE exposed for 6 months at sediment water interface. Plastic and biofilm was covered in needle mineral- like structures.

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