Impacts of Biofilm Formation on the Fate and Potential Effects of Microplastic in the Aquatic Environment

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Introduction

Every submerged surface is subject to **colonization by microorganisms** that built up a so-called biofilm. Therefore, it is indispensable to address possible consequences **biofilm formation** may have on the **fate, sink** and **effect** of Microplastic (MP).

Objectives

- **Review** the physical interactions of early microbial colonization and possible ecological consequences of biofilms on MP (Rummel et al., 2017[1])
- The JPI Oceans funded research project WEATHER-MIC addresses major aspects of the identified research gaps and first **results** are presented below.

Conclusion

- Biofilm formation on MP influences its **sinking behaviour**
- Additives and degradation products are **leaching** out of the polymers and may show **toxicity**
- The **formation of a biofilm** on PS and PET is a similar process with small differences the first few days of early colonization

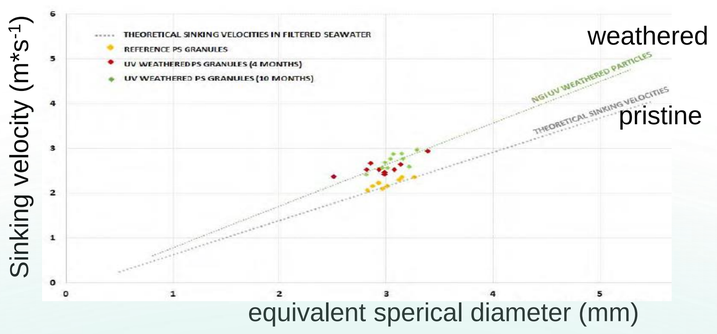
Chemicals

- Biofilms on MP present additional sorption sites for hydrophobic organic contaminants (HOCs)
- Biofilms may act as a barrier for diffusive uptake and release of chemicals by MP
- Some microorganisms are capable of metabolizing polymers and their additives
- The release of plastic additives may even promote microbial growth by serving as a nutrient source

Transport

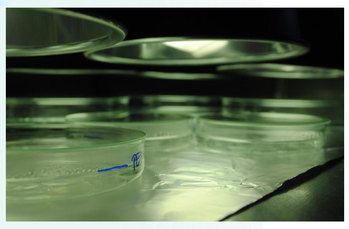
- Biofilms may lead to an increase of the overall density of MP
- The colonization of MP by microorganisms may promote the formation of heteroaggregates

→ Sinking velocities differ between weathered and virgin PS granules (results by Hans Peter Arp, NGI, Norway)

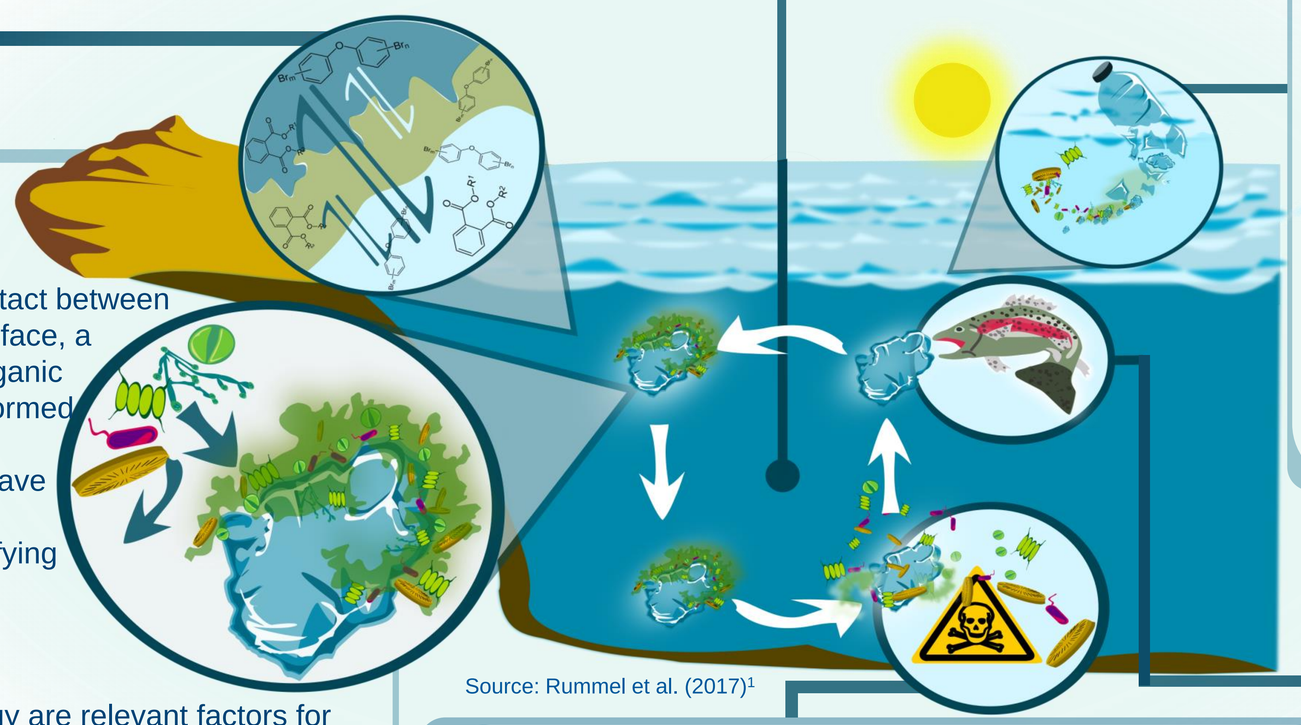


Weathering

- Successive fragmentation into smaller particles with a high surface-to-volume ratio is an important prerequisite for biodegradation
- Biofilms may shield plastic debris from UV light and promote its sinking to the aphotic zone
- Some microorganisms are capable of degrading synthetic polymers, plastizicers and to penetrate into the polymer structure
  → Abiotic weathering is simulated in the laboratory by strong UV light
  → Unkown degradation products may be present in the so-called leachate water



Artificial ageing under UV-light: chemical bonds are broken by UV-light leading to the formation of radicals. Subsequent formation of radicals propagate during autoxidation leading to chain scissions or crosslinking. By the combination of two radicals the reactions terminate when inert products are formed.[3]

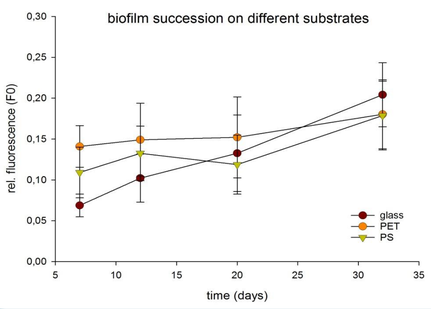


Source: Rummel et al. (2017)[1]

Attachment & Community

- Within seconds of the first contact between ambient water and a virgin surface, a conditioning layer or film of organic and inorganic substances is formed
- Initial conditioning films may have the capacity to govern the colonizing community by modifying the material-specific surface properties
- Surface properties and the organism's attachment strategy are relevant factors for successful attachment
- Microbial communities are the result of selection processes
- There is evidence for plastic-specific communities, so-called "Plasticsphere"[2]

→ Preliminary results show a small but significant difference in formation of biofilms in the first 30 days of growth between different polymers

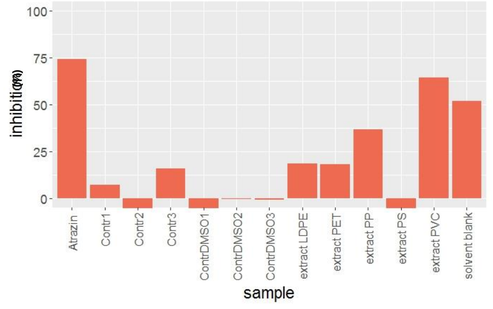


Biofilm succession on different synthetic polymeric substrates: The early formation of a biofilm on plastic substrates is similar on different plastic substrates (PET, PS) compared to the control (glass) when measuring the overall biomass using fluorometry (F0)

Toxicity

- Potential toxicological effects on biofilm-forming organisms may result directly from physical/ mechanical stress by the presence of solid particles (e.g., via adsorption of particles to the cell wall)
- Indirect effects may result from plastic-associated chemicals or additives leaching out of the polymer

→ Preliminary results show inhibitory effects of plastic extracts towards algae



Testing the maximum leachable fraction of plastics: solvent extracts of different polymers applied in an algae test using *Scenedesmus vacuolatus.* Plastic extracts show inhibitory effects. However, the solvent blank also displays high effects on algae growth.

Trophic transfer

- Primary consumers may preferentially ingest particles of higher nutritional quality, such as MP carrying nutrient-rich biofilms
- Biofilm formation and potential heteroaggregation may affect the uptake and susceptibility of organisms to ingesting MP by changing the physical properties and/or increasing the availability of MP particles.

Literature:
Rummel, C.D., Jahnke, A., Gorokhova, E., Kühnel, D., Schmitt-Jansen, M. (2017) Impacts of biofilm formation on the fate and potential effects of microplastic in the aquatic environment. Environ. Sci. Technol. Lett. 4 (7), 258 – 267
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