BONUS MICROPOLL

Deliverable 2.4 Report on MP degradation rates, which will be integrated into the models by WP5

Description of Work:

Experiments on MP degradation rates in artificial brackish water have been performed and published in Scientific Reports, Nature (see detailed description in the link to the publication below).

Exemplarily the degradation on plastics in artificial brackish water was tested on polyamide 6. Although incubating plastic particles over ~3 months, no biological degradation of the actual polymer structure could be detected. The measured increase in developed carbon could be attributed to monomeric structures which leach out of the polymer over time. These monomers can easily be biodegraded by Baltic Sea microorganisms and result therefore in the increase of CO_2 measured.

As a result we conclude that the degradation time for plastics in the environment is not on a relevant time scale to have to be integrated in the models established in BONUS MICROPOLL. This has been already communicated to WP5.

Link to the full paper can be found here: https://www.nature.com/articles/s41598-019-38685-6

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Residual Monomer Content Affects the Interpretation of Plastic Degradation

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Plastic degradation rates in the marine environment are essential to understand. This study demonstrates that in plastic-microbial interaction experiments, residual monomeric and oligomeric content of PA6 significantly influences the development of dissolved organic carbon. While it is well recognized that additives in plastics should be considered during the inception of plastic-exposure experiments, residual monomers have yet to be prominently considered in the same light. As such, in degradation studies where residual contents of monomers and/or oligomers are not considered, degradation of synthetic polymers could be significantly overestimated. The substantial conversion of these monomeric and oligomeric leachates also has implications for plastic-biofilm development studies and microplastic-biota-based ingestion experiments.

There are well-established and worldwide concerns about plastic pollution. As such, it is essential to understand the potential for degradation of plastics in the environment, especially the marine environment. Plastic degradation is defined as any physical or chemical change in the polymer resulting from light, heat, moisture, chemical action or biological activity that results in a decrease in the average molecular weight[1]. Typically, plastic degradation results in fragmentation of larger plastic pieces into smaller plastic particles by a combination of abiotic (such as UV irradiation) and biotic factors (extracellular enzymatic action resulting in biodeterioration/biofragmentation). When this process results in particles small enough to be assimilated by microorganisms, the final process of plastic degradation involves intracellular conversion into simple molecules such as CO_2[2,3]. Degradation tests for polymers in the marine environment are very specific and standardization procedures are not yet fully developed[4]. Another factor complicating research into plastic degradation is the complexity of plastic materials with regard to possible structures and compositions, making the testing of plastic degradability a highly interdisciplinary process[5]. Abiotic degradation and biodeterioration are usually investigated using physical tests. Biofragmentation is determined by the identification of fragments with lower molecular weight using chromatographic methods. Assimilation is often measured by the metabolite production or the increase of biomass. Mineralization is typically measured by ascertaining changes in either dissolved organic carbon, biological oxygen demand or CO_2 evolution (see Lucas *et al.*[3]).

Specifically designed biodegradable plastics notwithstanding, standard and engineering polymers (typically long-chain molecules from polymerisation, polycondensation or polyaddition) are generally considered to be resistant to biodegradation. The polyamides (PA) are one such important synthetic polymer belonging to the group of engineering plastics. PAs are considered to be biodegradable-resistant polymers[6,7], although some studies have demonstrated the biodegradation potential of some polyamides, particularly by fungi[8,9]. However, it may be that increases in carbon evolution, oxygen demand or biomass may be the result of microbial metabolism of residual monomers or oligomers, rather than the polymer chain. For example, PA6 (commonly referred to as nylon-6) is produced by ring-cleavage polymerization. During this process, some molecules fail to polymerize and remain as oligomers and monomers within the structure of the polymer. Although these components are by-products rejected by the producing factory[10], a small amount typically stays within the polymer. Depending on the further use of the plastic, manufactured polymers contain different amounts of residual monomers and oligomers (rM). The raw material of the PA6 tested within this study is the monomer ε-caprolactam, which is known

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Author Contributions

F.K. and A.T. present this work as dual-first authors. M.L. and F.K. developed the experimental design. F.K. and S.O. performed the experimental work. M.B. delivered the PA samples with specifically prepared rM content. F.K., A.T., M.B., I.S. and M.L. interpreted the data and discussed the results presented in the manuscript. A.T. performed the statistical analyses. F.K. and A.T. wrote the manuscript. All authors made comments and amendments, and approved the final version.

Additional Information

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