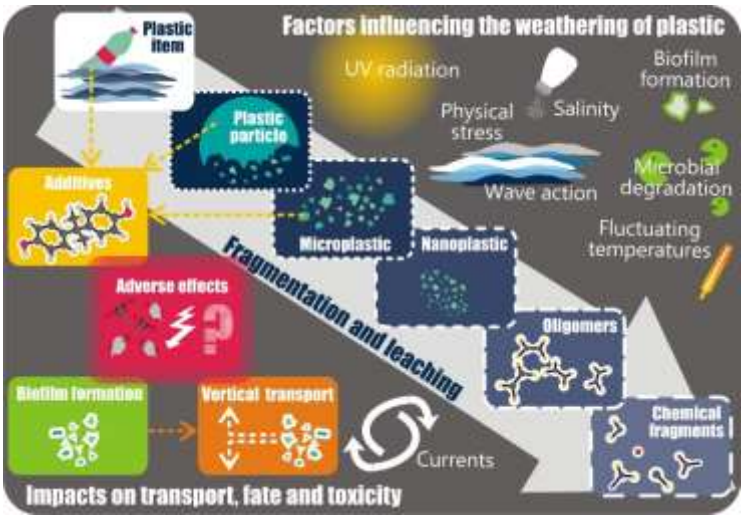
WEATHER-MIC –

How microplastic weathering changes its transport, fate and toxicity in the marine environment



Project acronym: WEATHER-MIC

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[WEATHER-MIC] website address: http://jpi-oceans.eu/weather-mic/about

PUBLISHABLE SUMMARY

The overall aim of the WEATHER-MIC project is to assess how microplastic weathering changes its transport, fate and toxicity in the marine environment. Microplastic in the ocean is exposed to UV light, wave action, biofilm growth and other weathering factors. These factors lead to fragmentation, degradation, and surface modifications, changing the density and particle size distribution of the microplastic, which ultimately impacts their environmental fate and transfer in food webs. Despite the importance of these aging processes and their related impacts, the hazards associated with weathered microplastic are not well understood yet. To achieve better knowledge about how weathering influences the physicochemical properties, environmental fate and toxicity of microplastic, we carried out several research activities divided into seven scientific work packages (WPs).

Research activities in WP1 at ACES were focused on experiments and data interpretation related to artificial weathering of plastic in our "weathering wheel". We published a paper in Environmental Science & Technology Letters (Gewert et al. 2018) that describes the identification of free chemicals in water that were liberated under artificial weathering as chain scission products of plastic. This paper provided a major building block for further experiments aiming at development of a "fingerprinting" method for plastic leachates based on their mass spectroscopic signals. Method development has been completed using idealized samples that consist of clean sand containing one of six different known plastic types. Analysis of these idealized samples indicates that unique mass spectroscopic fingerprints of each plastic polymer could be identified following artificial weathering. Work to demonstrate that unknown mixtures of plastic materials can be identified using this method is nearing completion, and a paper describing this work is expected in 2019.

The main tasks conducted by WP2 at NGI included developing the 1DV settling model for irregular microplastic shapes, in coordination with KUL (WP4), and to integrate the recent weathered microplastic data from IKTS as part of developing ways to account for weathering effects on settling behavior. In addition, much activity was done in WP5 to quantify microplastic in sediment cores from the Oslo Fjord, as well as microplastic in sediment and water samples taken off the coast of Havana as part of the collaboration with Race for Water.

Our partner IKTS further focused in WP2 on the characterization of weathered LDPE and PET samples. Not only existing methods were optimized, but new methods were developed and standardized. The carbonyl index is a parameter that is very suitable for evaluating the influence of UV light on plastic during weathering. It was determined by means of FTIR analyses. For LDPE, a UV light-induced tendency to embed oxygen in the chemical structure was shown. In addition to the chemical properties, changes in the surface properties also occurred as a result of weathering. Streaming potential measurements on PET sheets confirmed that growth of biofilm leads to changes in surface charges. These new methods can also be applied to naturally aged samples. Important data concerning the ratio of biofilm volume to polymer volume are determined by computer tomography. Together with the results of the density analyses, which are based on a flotation method and take into account the influence of the biofilm, the final biofilm density can be calculated. The data are of particular interest for sedimentation and distribution models of microplastic in the aquatic environment (WP4).

Our partners at ACES focused on integrating experimental results on biofilms and their effects on microplastic behavior in hazard testing and settling in the water column (WP3). Protocols for stable-isotope labeling of biofilm and quantitative analysis of biofilm communities on microplastic particles were established and are in preparation for publication. These methods are instrumental to measure transfer of the bacterial biomass in the system, including sediment-living microorganisms and animals consuming particles that carry biofilms. Also, for evaluating fitness-related consequences for consumers, a novel concept of a standard testing procedure for establishing effect concentrations of microplastic has been developed and submitted for publication. To discuss ideas and facilitate

collaboration between WP3 and WP4 regarding modeling of MP, we organized a research visit to KUL. Based on the results of WP3, funding for a project "Towards quantifying impacts of microplastics on environmental and human health" (2019-2021; Swedish EPA) was secured.

In WP4 (KUL), analysis of settling rate data for various types and shapes of MP particles showed that they follow the expected trend for similarly shaped particles, known from fluid mechanics, and confirms that the settling behavior is entirely governed by the dimension and shape (characterized by the 3 principle length scales), relative particle density and the fluid viscosity. Weathering may be reflected in changes of density and as a consequence leads to a shift on the trend line. Changes in surface properties do not seem to play an important role, relative to the uncertainty band around the mean trend. Microplastic particles seem to be easily captured in aggregates, and the settling behaviour of these aggregates follows the same trend curve.

At UFZ, we tested particles of different size classes and leachates after UV-weathering by applying a high-throughput algal assay using several biological endpoints of synchronized cultures of the chlorophyte *S. vacuolatus* as part of WP6. While in the fraction <1.2 µm the amount of PET particles doubled after weathering, LPDE did not show any differences. Furthermore, no effects of the different size classes on algal performance were found. Similar results were obtained in the *D. magna* assay. Concentrated leachates of PE, PP, PS and PET were tested against positive controls (e-waste and a new keyboard) in the algae test and cell-based bioassays. E-waste leachates had strong effects, while the pre-production polymers showed only slight or no effects. In some cases, we observed stronger effects of the leachates generated under UV light irradiation in comparison to the dark controls, indicating a UV-induced leaching of compounds that create effects.

The main aims of WP7 were to provide estimations of the environmental risk posed by the weathering process. Fragmentation of plastic items as well as the leaching of degradation products and additives needs to be considered in this regard. Experimental data generated within WEATHER-MIC were complemented by relevant data from the scientific literature. The literature research focused on leaching processes and the impact of leachates on biota. Literature data indicate that weathering increases release rates of additives, but not the total amount that is being liberated. Leaching studies focus mostly on additives, whereas little data exist on polymer degradation products. For risk assessment, the ongoing degradation of substances in the leachates needs to be taken into account.

As part of WP8, the outcomes of the project were presented at the JPI Oceans Final Conference on Lanzarote on November 20, 2018. WEATHER-MIC scientists contributed to a range of meetings and expert workshops in 2018, such as "Thresholds for Marine Litter" organized by the MSFD technical group on marine litter and a related panel discussion on Lanzarote. Several partners participated in the interdisciplinary Berlin University of the Arts & Technical University Berlin project "Microplastics and Medusae" recently on display at the Universal Sea Festival in Budapest. Furthermore, WEATHER-MIC scientists participated in a range of interviews for the press, internet, radio and television, and were present at the press conference for the opening of the Ocean Plastics Lab in Berlin. WEATHER-MIC scientists were also active in many other seminars and conferences. For examples, please see: http://www.jpi-oceans.eu/weather-mic/about