Determination of temporal changes of POP sorption and plastic additive release as well as spectrometric characteristics to a variety of polymers under Arctic marine conditions

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Introduction

The JPI OCEAN project PLASTOX investigated the ingestion, food-web transfer, and ecotoxicological impact of microplastics (MPs), together with the persistent organic pollutants (POPs), metals and plastic additive chemicals associated with them, on key European marine species and ecosystems. PLASTOX combined field-based observations, laboratory tests and manipulative field experiments to study the ecological effects of MPs. In 2017 and 2018 a set of field campaigns were carried out in Arctic marine environments, including Svalbard, where virgin plastic pellets from a variey of polymers and particles derived from used plastic were deployed. The aim of the study was to investigate the sorption patterns of existing environmental POPs to different polymer materials and to study the potential release of additive chemicals from the same materials.

Materials and methods

As part of a long-term field experiment within PLASTOX that was conducted at marine locations across Europe (Mediterranean to Arctic), a range of different virgin polymer pellets, post-use polymers (LDPE, PP, PS and PET), and marine litter-derived microplastic particles were deployed underwater for up to 12 months in the small boat harbour of Tromsø, Northern Norway (Figure 1). The deployment device consisted of an empty stainless steel canister with the various plastic test materials placed in reusable, empty 'teabags' made of PP, which were in turn placed separately in nylon netting. Sampling was conducted 1 week, 1 month, 3 months, 6 months and 12 months after deployment. A second deployment experiment was carried out on Svalbard, Ny Ålesund, in the form of two 6-months campaigns, one for the winter- and one for the summer season, also incorporating ice cover in the evaluation. For all sites, hydrophobic persistent organic pollutants such as PCBs, PBDEs and HCB were measured. For comparison, plastic litter collected on the beaches of Svalbard was analysed for the same POPs. Simultaneously, FTIR and DART mass spectrometry analysis was conducted for each material over time. This allowed changes in the IR and MS spectra due to weathering to be documented. Samples were extracted using a combination of ultrasound and non-polar solvents, and subjected to GPC and SPE clean up prior to chemical analysis and quantification by GC/HRMS.

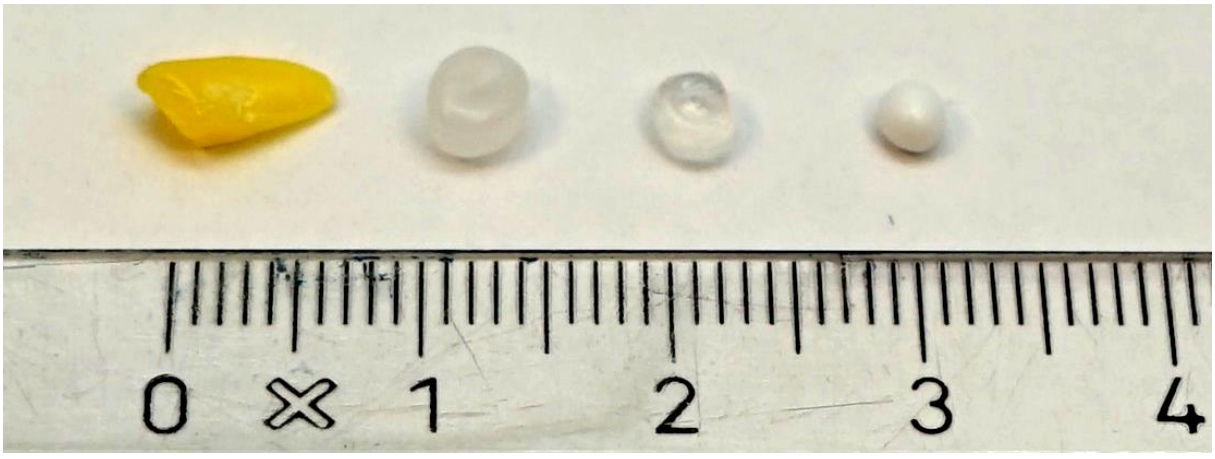


Figure 1: Plastic pellets analysed in the project, from left to right: PE-HD (≈ 5 mm), PE-LD (≈ 4 mm), PP (≈ 3 mm) and PET (≈ 2 mm).

Results and discussion:

Results show that HCB and PCBs (expressed as sum halogenated organic compunds (sumHOCs)) represented the dominant pollutant classes adsorbing to all of the different polymer types, but at concentrations that are more than 10-times lower than those previously reported in more temperate environments [1]. Results also indicated that equilibrium between the POPs and the polymers was not reached during the deployment period, suggesting that Arctic conditions may result in different sorption kinetics than those observed in temperate regions. The data from the field experiment from Svalbard showed a similar pattern with some variations. The assessment of Arctic winter- and summerconditions, revealed polymer dependend differences, with virgin PE showing the strongest seasonal dependency with up to 5 times higher sumHOC after three months under winterconditions, compared to summer (Figure 2). No seasondependcy was observed for the other polymers.

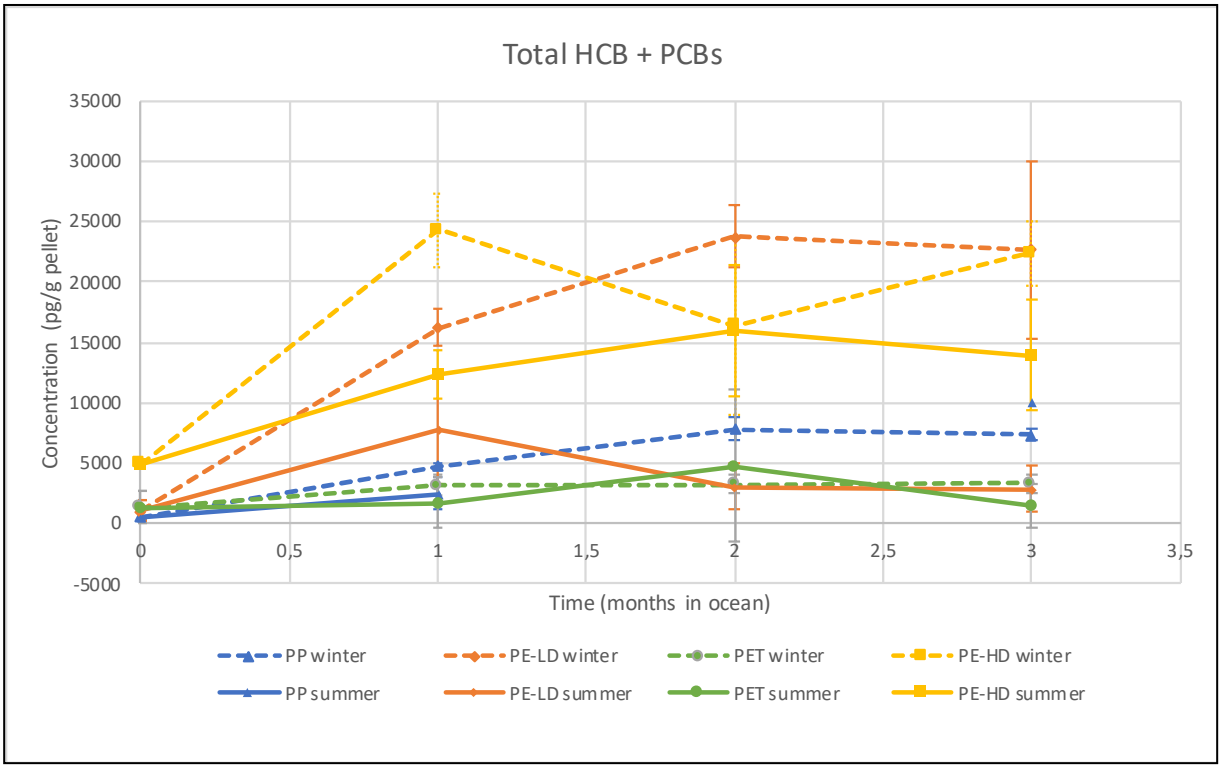
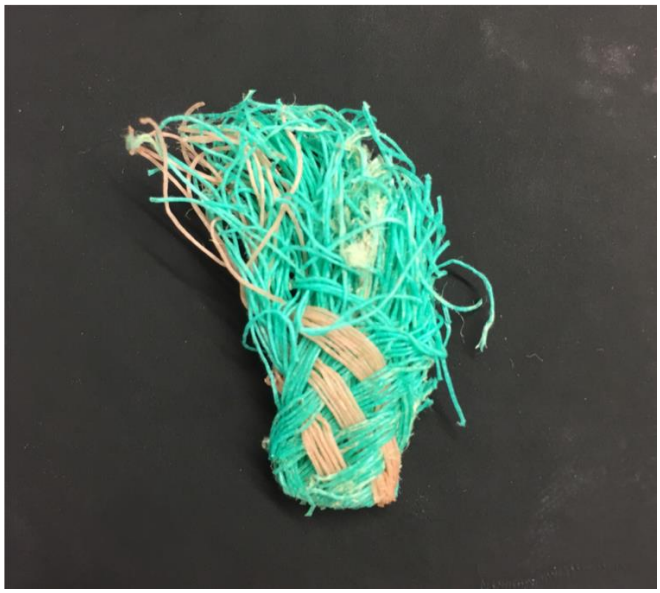


Figure 2: Total HCB and PCB concentrations (pg/g pellet) (y-axis) in PP, PE-LD, PET and PE-HD the three first months (x-axis) in the ocean during summer and winter time in Ny Ålesund, Svalbard. Standard deviations are included (vertical lines). Please note that the values of summer PP at month number 2 is missing.

The plastic litter samples collected on Svalbard (n = 17), showed a very inhomogenously distributed POP load, with extreme concentrations up to 350 ng/g plastic for sumPCBs and 160 ng/g plastic for sumPBDEs. However, other samples showed no detectable POP levels. The polymer composition of the investigated samples consisted of 39% PE, 39% PP, 7% PS, 7% PC, 4% PA and 4% PET, with the most extreme POP loading associated with the PE materials.

Imaging of the test materials with scanning electron microscopy revealed abrasions and the formation of fragments in the low micrometer size, as well as visible changes occuring during wintertime and icecover relative to summer time (Figure 3).



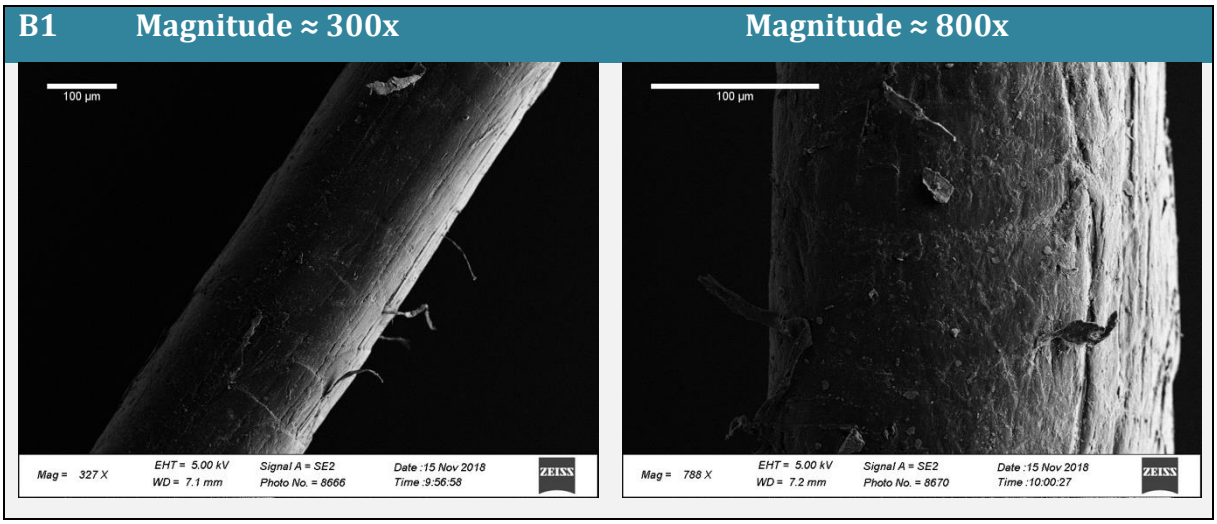


Figure 3: SEM pictures of a plastic litter sample at magnitude ≈ 300x (left) and ≈ 800x (right).

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References

[1] Rochman, C. M., Hoh, E., Hentschel, B. T., Kaye, S. Long-term field measurement of sorption of organic contaminants to five types of plastic pellets: implications for plastic marine debris. *Environmental Science and Technology*. **47**, 1646-1654 (2013)