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Marine Macro- Meso-, Microplastics and Fungi in Polar Regions of the Northern (Longyearbyen, Svalbard) and Southern Hemisphere

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1. INTRODUCTION

Although plastic pollution is ubiquitous, and remote polar regions are no exception, relatively little is known about the presence of polymers in the Arctic and Antarctic. Additionally, basic data to perform the modelling of their transport, fate, and environmental behaviour are insufficient. Within this work, we provide information about the polymer types present in the polar environment through spectral identification of specimens from Longyearbyen (Svalbard) and the Falkland Islands. Both places were intentionally selected to compare the northern and southern hemispheres. The Arctic, being under higher anthropogenic pressure, is a perfect place to understand the long-term interaction between plastic debris and biota. In particular, fungi were selected to be studied as promising bioindicators. Thus, research on the fungisphere composition has been conducted. In contrast, the relatively little-contaminated Falkland Islands can be used as a model zone to speculate on the origin, transport, and fate of microplastics.

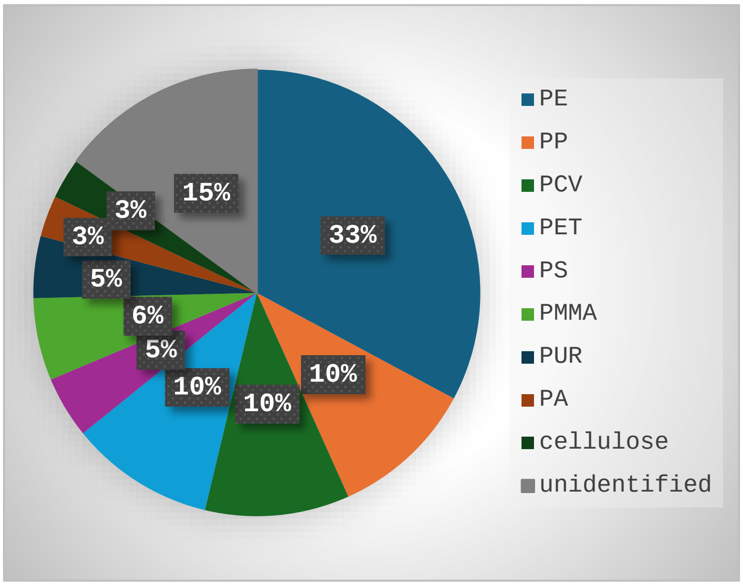
2. LOCAL MICROPLASTIC SOURCES (LONGYEARBYEN, SVALBARD)

Plastic specimens were collected at Longyearbyen beach in the summer season (2023). Several protocols were tested, with the most promising one named "local sources". Within this approach, further study was conducted on macroplastics, around which meso- and microplastics were observed, confirming the advanced and increasing fragmentation. All samples were identified, and the most abundant types were used for the fungisphere detection.

2.1 Spectral Identification

Samples were qualitatively identified by ATR-FTIR, FTIR (in a mapping mode), and Raman spectroscopy. The main identified plastics were PE – 33%, PP, PVC, and PET – 10%, PMMA – 6%, PS and PU 5% each, PA and cellulose 3% (Fig. 1A). The percentage of unidentified polymers was 15%, mainly due to the strong deterioration or organic matter contamination (Fig. 1B).

A)



B)

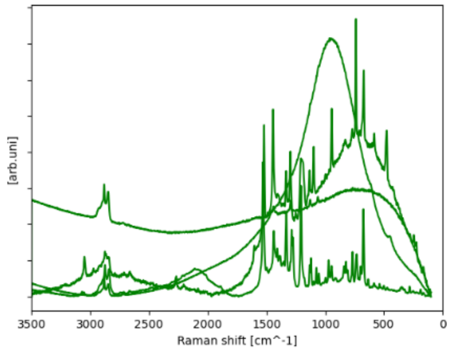


Fig. 1: A) Polymer types at Longyearbyen; B) Examples of MPs spectra at different levels of ageing and biased by self-luminescence.

2.2 Fungisphere characterization

Plastic samples were placed on three different selective culture media (with rPET, mineral oil and polystyrene as the main carbon sources) and incubated for six weeks at 22 °C. 35 strains were isolated and identified based on ITS rDNA sequencing and additional molecular markers. These strains were classified into 21 taxa. Of the 21 fungal taxa isolated, 15 have been reported in the literature as capable of degrading plastics. The identified taxa included representatives of the classes *Dothideomycetes, Hypocreales, and Leotiomycetes*, which had previously been isolated from the Svalbard plastisphere (Rüthi et al. 2023). Fungal colonies on the surface of the samples after 6 weeks of incubation are presented in Fig. 2.

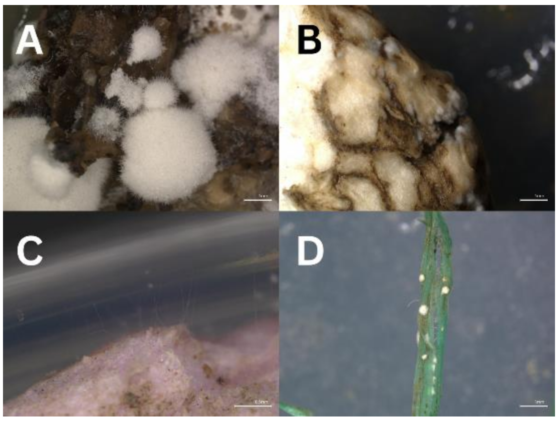


Fig. 2: A – Sample H5-H6-6, *Trichoderma* sp. colonies, scale 1 mm; B – Sample H5-H6-2, *Pleospora richtophensis* colonies, scale 1 mm; C – Sample HH8F, hyphae reaching the lid of the Petri dish, scale 0.5 mm; D – Sample HH1, Entomortierella parvispora species complex colonies, scale 1 mm.

More than 400 organisms are known for their ability to degrade plastics, including fungi (Ekanayaka et al. 2022). The ability of selected isolates to colonize polypropylene when grown on MEA (malt extract agar) was tested and confirmed for 12 out of 19 isolates. Subsequently, the ability of strains of *Alternaria alternata* and *Trichoderma* sp. to colonize polypropylene and polystyrene was examined, with these plastics serving as the main carbon source. All tested strains were capable of colonization, although differences in efficiency were observed. *Trichoderma* sp. strains showed a preference for polystyrene, while *A. alternata* preferred polypropylene. Although the experiments conducted are not sufficient to confirm the ability to degrade plastics, colonization and adhesion to the material are necessary conditions for biodegradation and represent its first stage (Oliveira et al. 2020), indicating the potential for synthetic material biodegradation by Arctic fungi.

3. TRACKING MICROPLASTIC FATE AND TRANSPORT (FALKLAND ISLANDS)

Figure 3 presents an overview of the polymer identification within different zones of the Falkland Islands. Zones under tourist anthropogenic pressure (Port Stanley during the cruising period) were compared. Obtained results suggest that the main sources of microplastic contamination are related to the ghost nets from the calamari industry brought by the plastic tide on shore (north and western parts of the archipelago), and touristic litter. Local conditions primarily influence abiotic degradation and can be precisely modelled.

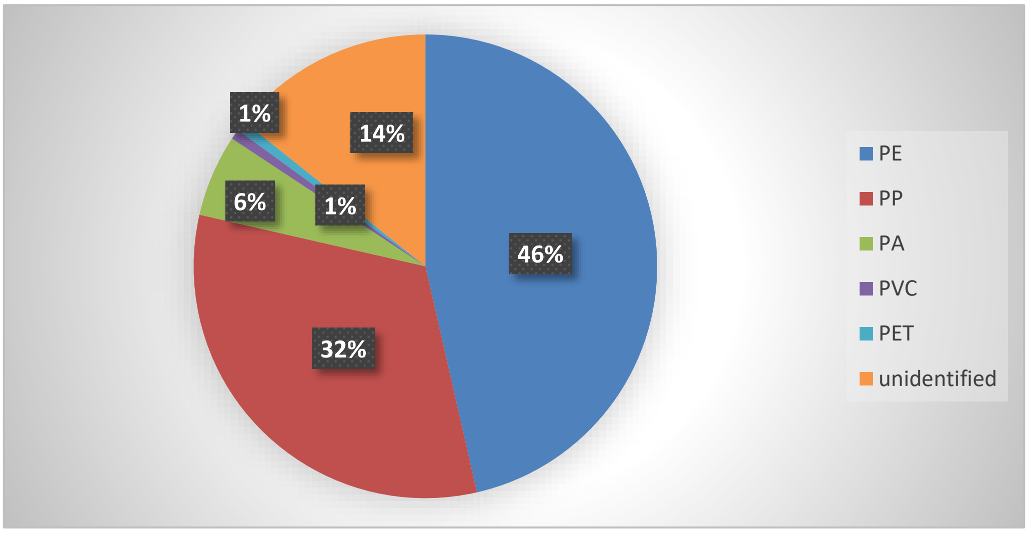


Fig. 3. The FTIR ATR test results show that the main identified plastics were PE – 46%, PP– 32%, PA – 6%, PET and PVC 1% each. The percentage of undisinfected polymers was 14%.

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