Microplastic alteration in agricultural soils across Europe: Comparative study of MPs inside and outside soil aggregates over two years

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Introduction

- **Mulch films** act as a **major source** for **microplastic (MPs) in soil**
- **Biodegradable plastics** as **alternative**, as they are supposed to **completely degrade** after their service life
- But **conventional** and **biodegradable plastics fragment** into **MPs** during application
- **MPs** are a part of the **soil aggregate formation**
- **MPs** occluded in **aggregates** are **shielded** from **weathering processes**

Question: Does occlusion in soil aggregates affect MP weathering?

Materials & Methods

Field experiment (Papillons Project)

- **Finland, Spain and Germany**
- **0.05 %** of **LLDPE** and **PBAT/Starch MPs** (< 1 mm)
- **Soil sampling (0-10 cm)** in **2022** and **2023** after barley growing seasons

Methods

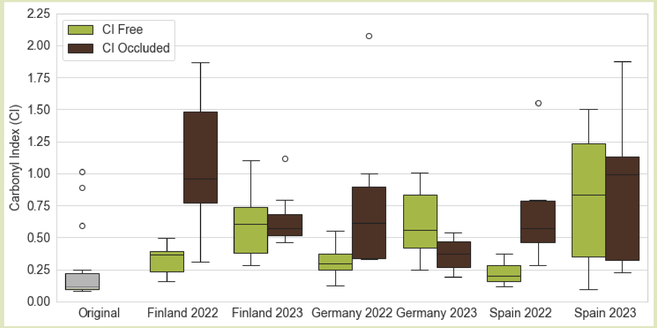
- Separation of **"free"** and **"in soil aggregates occluded" MPs**
- Scanning electron microscopy (**SEM**), Fourier-transform infrared spectroscopy (**FTIR**), nano-X-ray computed tomography (**nano-CT**)

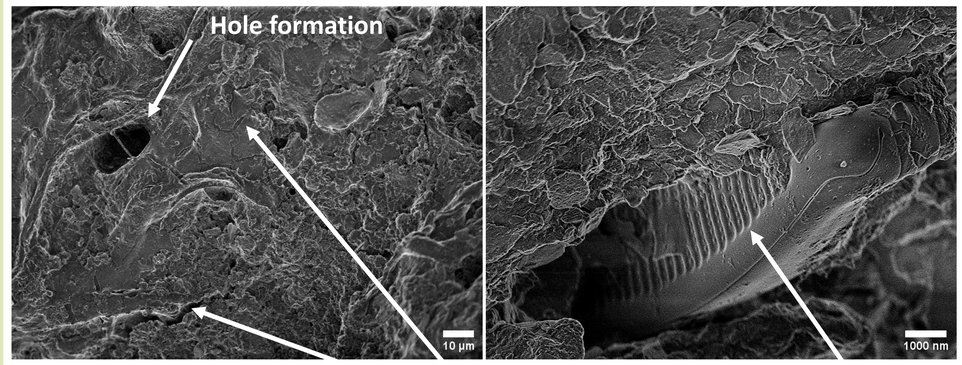
Conclusion

- Signs of **weathering for LLDPE and PBAT/Starch MP**
- **SEM and CI** show **no differences** for **free and occluded LLDPE MPs**
- **Nano-CT** reveals **changes in PBAT/Starch MP structure**
- **Two-Dimensional Correlation Spectroscopy → differences** in **degradation order** between **free and occluded PBAT/Starch MPs**

Linear Low Density Polyethylene (LLDPE)

$$Carbonyl\ Index = \frac{1650 - 1850\ cm^{-1}}{1420\ - 1500\ cm^{-1}}$$



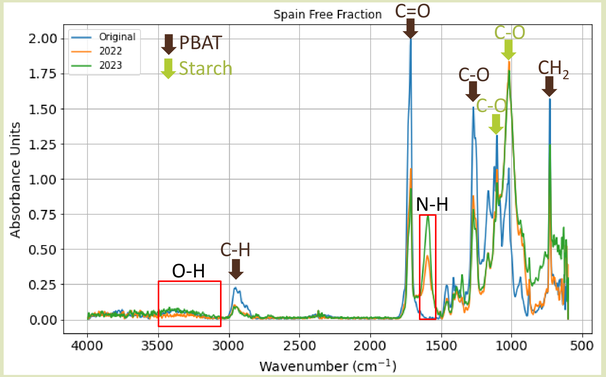


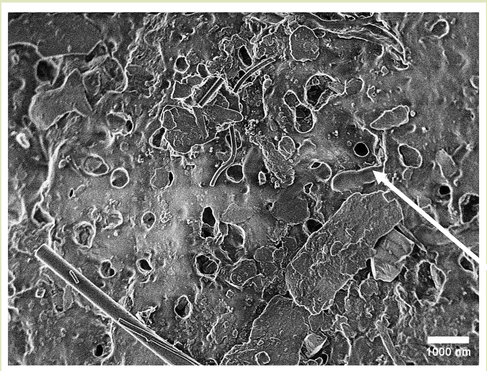
- **Carbonyl Index (CI) increases** for **free MPs** with **increasing soil exposure time in all countries**
- **CI** shows **no uniform trend** for **occluded MPs → heterogenous conditions** inside aggregates
- **Signs of weathering on all MPs → no differences** between countries and free and occluded MPs

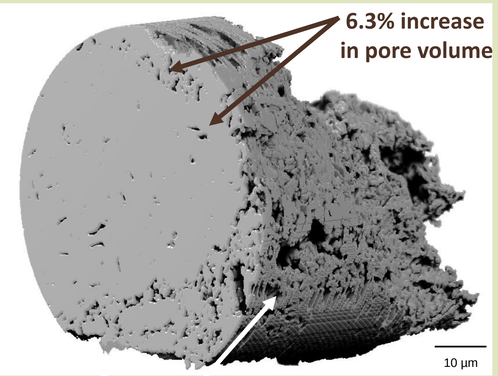
Increase in surface roughness

Colonization of surface by soil organisms

Polybutylene Adipate Terephthalate (PBAT)/Starch







- **Formation** of **functional groups** and **changes in peak intensity** for all **PBAT/Starch MPs**
- In **free MPs,** the **starch** phase **degrades before** the **PBAT** phase, **in occluded MPs** the phases degrade at the **same time**
- **Weathering** affects the **surface** and **structure** of **PBAT/Starch MPs**

degradation of starch granules

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