2nd Conference on Green Chemistry and Sustainable Coatings

greenchemco

Pisa, Italy, 28th-30th June 2023

Monitoring of plastic degradation by microbial communities, worms and insects

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Keywords: plastic waste, biotechnology, biodegradability, chemical imaging analysis, biomass valorisation

Introduction

After a turbulent period, linked to the Covid-19 emergency, global plastic production is growing again, and 390.7 Mt were produced in 2021 of which up to 44% are consumed by the packaging and agricultural-farming industries, respectively. In Europe, in 2020, 29.5 million tons of post-consumer plastics waste were collected, of which about 50% is mixed and not adequately separated, and disposed in landfills (38%), incineration (57%) while only 5% is recycled.
BBI JU H2020-funded RECOVER project aims to explore routes for the biotechnological recycling of waste plastics from food packaging and agriculture (AWP, Agri-food Waste Plastics) which represented the 42.2% of total plastic demand in Europe in 2021, and their removal from soil and compost by three synergistic and cooperative actions of: a) microbial communities, b) earthworms and c) insects, to convert plastics into biofertilizers and bio-based materials for food packaging and agricultural applications (Figure 1). UNIPI partner monitored AWP degradation by thermal, morphological and structural characterizations, and the valorization of chitin/chitosan extracted from insect exoskeleton

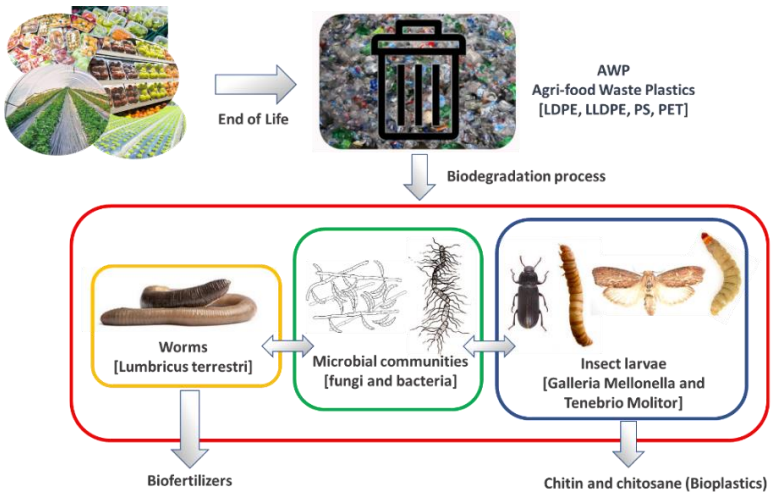

Figure 1. RECOVER objectives

Material and methods

Differential scanning calorimetry (DSC), thermogravimetrical analysis (TGA), Fourier transform infrared spectroscopy (FTIR), gel permeation chromatography, chemical imaging analysis and optical microscopy were used to characterized AWP samples (LDPE, LLDPE, PS, and PET) after treatment with: a) two microbial communities (consortium C2 constituted by Bacillus subtilis, Fusarium oxysporum and Alternaria alternate and consortium C4 constituted by Bacillus subtilis and Pseudomonas putida); b) Tenebrio Melitor and Galleria Mellonella larvae without and with the inoculation on the insects of both endogenous and exogenous microorganisms; and c) earthworms (Lumbricus Terrestri) without and with fortification by recover complex carriers (RCC).

Results and Discussion

AWP powder, recovered after the microbial communities' treatments, did not show significant differences compared to control samples in bulk analyses (DSC, TGA). On the contrary, optical images, chemical maps and FTIR analysis highlighted evident changes in the chemical composition in the surface area of the polymer samples, especially for PET and LLDPE, confirming microbial degradation (Figure 2a, related to PET treated with consortium C2). Likewise, in the case of the treatment with insect larvae, the effect of the degradative attack was detected on the surface of the polymeric samples (Figure 2b related to LDPE sample treated with Tenebrio Molitor larvae) where new oxygenated functionalities were observed. Moreover, thermal and spectroscopic characterization on the LDPE polymeric fraction extracted from Tenebrio frass, confirmed that, even some LDPE debris were present, the polymer was significantly degraded. Finally, degradation effects were also detected in the case of treatment with earthworms. Optical micrographs showed a quite eroded and frayed edges in the treated plastic films.

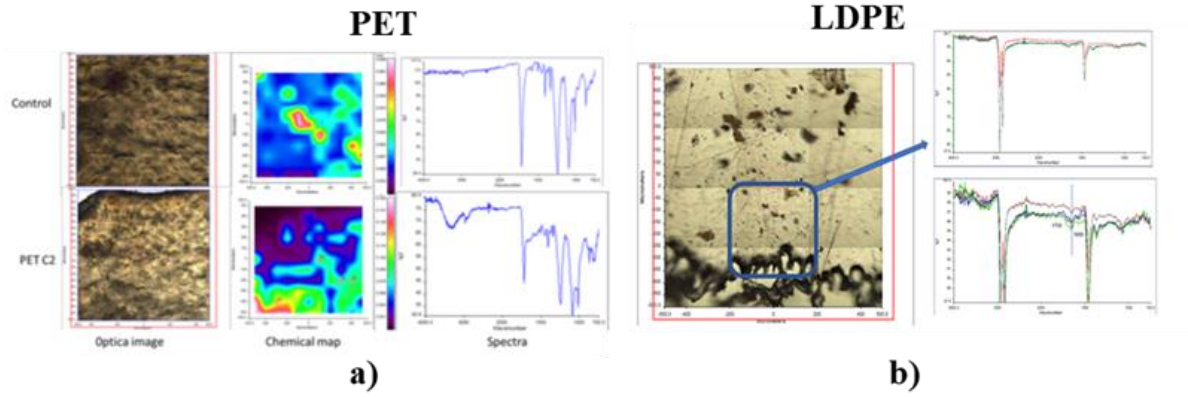

Figure 2. a) optical image, chemical map and FTIR spectra of PET before and after microbial degradation; b) optical image and FTIR spectra of LDPE sample after treatment with Tenebrio Molitor larvae.

Conclusions

Significantly encouraging biodegradative effects were detected on AWPs by the action due to microbial communities, insect larvae and earthworms.

Acknowledgements: This project has received funding from the Bio Based Industries Joint Undertaking (JU) under grant agreement "GA887648" project RECOVER "Development of innovative biotic symbiosis for plastic biodegradation and synthesis to solve their end of life challenges in the agriculture and food industries". The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium.

Biography

Giovanna Strangis is a Ph.D student at the Department of Civil and Industrial Engineering of the University of Pisa, where she graduated in Materials Engineering. Her research project is focused on the recycling of plastic materials through innovative and green techniques. She is currently working on the mechanical and thermal characterization and reprocessing of different plastic materials, which are the main causes of land and sea pollution. In particular, she is studying the procedures of reuse of materials from fishing nets and food packaging.