UNIVERSITY OF MESSINA

Department of Chemical, Biological, Pharmaceutical and

Environmental Sciences

Ph.D. course in Applied Biology and Experimental Medicine

XXXVII Cycle

SSD: BIO/07

STUDY OF THE DEGRADATION OF THE BIOPOLYMER MATER-BI® AND EVALUATION OF THE EFFECT ON MARINE ORGANISMS UNDER A CLIMATE CHANGE SCENARIO

Ph.D. Thesis of:
Serena Scozzafava
Serena Scozzafave

Tutor UniMe:
Prof. Nunziacarla Spanò

Tutor SZN:
Dr. Teresa Romeo

Coordinator:
Prof. Emanuela Esposito

2024

SUMMARY

Anthropogenic pressures on coastal ecosystems are large and diverse, with concurrent impacts such as pollution and fishing pressure now accumulating and interacting with the effects of climate change (e.g. global warming, acidification and sea-level rise). In recent years, marine plastic pollution has become a critical issue on a global scale, particularly due to its degradation in water resulting in the formation of microplastics (MPs). The significant amount of marine plastic debris poses physical hazards to marine wildlife through entanglement or ingestion, resulting in serious physical injury, death, or negative effects on behavior and ecological interactions. The persistence of plastics in the environment depends on several factors, such as the properties of the plastic itself and the chemical-physical properties of the environment, making the research on plastic pollution challenging especially in a changing climate. Plastic pollution and climate change are two of the greatest environmental challenges of our century and are closely linked.

Increased awareness of mismanaged waste and its impact on the environment has led to a growing interest in the use of bioplastics to replace conventional plastics.

A successful example of bioplastic is Mater-Bi®, composed mainly of starch with a small proportion of natural plasticizers. Therefore, in the natural environment, the degradation process is different due to the combination of abiotic degradation (the effect of physic-chemical parameters) and biotic degradation (microbial activities). Several analytical techniques have been used in different experiments in the field and in the laboratory to monitor and evaluate the degradation process of plastic materials in the marine environment. Regarding the degradation of plastics and bioplastics, most studies rely on long-term exposures of 6-24 months.

For this reason, this work focused on a combination of different observations varying from one month to one year to assess the degradation in the marine environment of the biopolymer Mater-Bi® compared to conventional plastic (polypropylene and high-density polyethylene).
Since marine litter is generated from approximately 80% of land-based sources and the remaining 20% comes from sea-based sources, two different products from each source were selected for this study. In particular, mussel nets are the seventh most frequent item found on beaches and the common shopping bags used in everyday life are the most abundant packaging found as waste in the environment **(Chapter 1)**. Thus, **Chapter 2** aims to evaluate the potential use of Mater-Bi (MB) socks in a mussel farm located in the Ionian Sea (Mar Piccolo, Italy), while **Chapter 3** deals with the study of the degradation of shopping bags in the marine environment.
In both case studies, in addition to the physical and mechanical properties of the polymers, assessed through various approaches such as visual inspection, weight, modification of the polymer surface

and study of tensile properties, the biotic component was also evaluated. The biodiversity associated with plastics and bioplastics was studied through the analysis of the plastisphere assemblages (microbial and microphytobenthos community), but also through the measurement of mussels reared on socks and the study of the macrofaunal community associated with them.

Finally, given the need to understand the interactions between plastic pollution and climate extremes and to disentangle the effects on marine ecosystems, a multiple stressor mesocosm experiment was conducted (**Chapter 4**). Mesocosm experiments play a crucial role in investigating impacts on organisms by creating controlled environments that allow mimicking real-world conditions and realistically manipulating variables such as extreme temperatures and microplastic contamination.
The bivalve *Mytilus galloprovincialis* is the most farmed species in the Mediterranean Sea, but also a model species in experimental studies. Due to its importance, it has been selected for this research to investigate the effect of conventional and bio-based MPs and extreme water temperature on its functional traits (i.e. behavioral, physiological, and morphological characteristics).