Corso di Dottorato di Ricerca in Scienze della Vita e dell'Ambiente, Ciclo XXXVIII

Presence, behaviour and effects of Microplastics in marine environment

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INTRODUCTION

Microplastics (MPs), commonly defined as synthetic particles <5 mm in diameter are increasingly proving to be ubiquitous in all marine ecosystems and coastal areas. To address their distribution, bioavailability and effects, novel tools and integrated strategies are required. Since problems with plastic pollution are some of the biggest challenges of our time, biobased plastics have emerged as a promising alternative to synthetic ones. However, the real opportunities and risks of such novel biobased plastic solutions have raised scientific and public awareness. In this PhD, our primary objective was to investigate the distribution of MPs in different environmental matrices and the possible biological effects. We conducted monitoring activities utilizing new bioindicators, as well as exposures in laboratory settings and mesocosms. The use of innovative bioindicators allowed us to obtain more precise and reliable data on environmental quality, enhancing our ability to detect contaminants and ecological stressors. Laboratory exposures enabled us to control and replicate specific conditions to assess the fate of MPs in marine environment. Additionally, mesocosms provided a bridge between laboratory experiments and field studies, allowing us to observe ecological impacts in a more realistic and controlled context. These combined approaches have improved our understanding of ecosystems and their responses to environmental pressures, offering effective tools for environmental management and conservation.

AIMS

The PhD project aimed to characterize plastic and microplastics pollution in coastal marine- and land-based areas applying strategies based on:

i) the monitoring of plastic and microplastic in biotic and abiotic matrices of the Conero area,

ii) the introduction of novel bioindicator species such as insects and macroalgal forests in order to estimate the distribution and the bioavailability of plastic pollutants in coastal, marine and shrubland ecosystems,

iii) the investigation on possible biological effects associated to biobased polymers compared to conventional plastics.

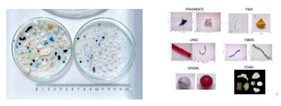
MONITORING OF MPs IN MARINE ENVIRONMENT

SAMPLING AREA
Conero Riviera
(Central Adriatic Sea)

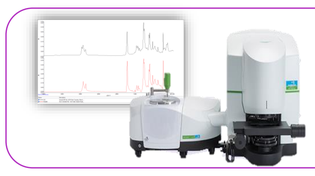
EXTRACTION AND CHARACTERIZATION OF MICROPLASTICS

Pre-treatment of the sample and vacuum filtration

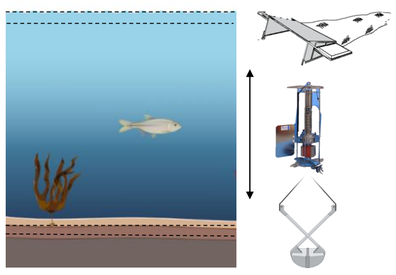
Visual sorting



Physical characterization of isolated MPs



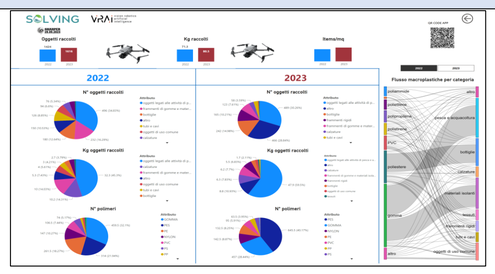
Chemical identification through micro-FTIR spectroscopy.



Biotic matrices:
Mitylus galloprovincialis
Ulva spp.
Gongolaria barbata
Cystoseira compressa
Carabidea spp.
Oniscidea spp.

Abiotic matrices:
Surface water
Water column
Sediment

RESULTS



Surface water: 1.52 ± 1.96 MPs/m^3

Water column: 43.5 ± 8.225975 MPs/m^3

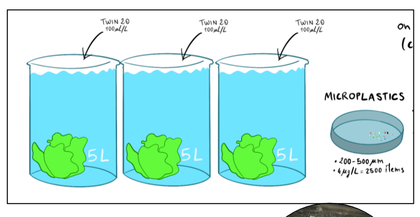
Sediment: 5 ± 2.36 MPs/kg

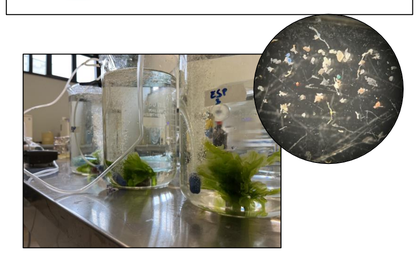
Algae: 0.8 ± 0.77 MPs/w.w

Mussels: 1.31 ± 0.07 MPs/organism

Carabidea spp.: 1.05 ± 0.88 MPs/organism

ASSESSMENT OF MPs TRAPPING CAPACITY IN *ULVA SPP.*

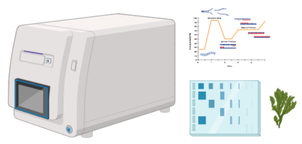




Species: *Ulva* spp.
MPs:
- Field collected and micronized
- Size range 200-500 µm
- Polymers: PP, PE, PET, PS, PVC

Treatment: Artificial Sea Water with 500 MPs/L and surfactant Tween 20.
Phase 1: 1h/24h exposure to MPs
Phase 2: 1h/24h rinsing phase

Morphometric measures of thalli:
- Dry weight
- Area
- Fractal dimension & Lacunarity



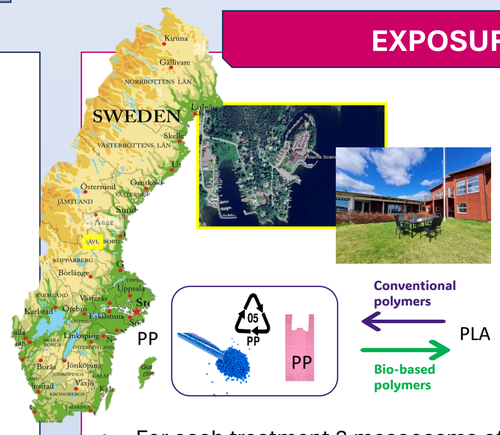
DNA sequencing of *Ulva spp*.

RESULTS

Date	species	replicate	tween	exp_time	items_retained	dw	items/dw	items_released	tot_captured	not_captured
apr-23	ulva_1	1	N	1	90	0.98	91.835	314	404	2096
apr-23	ulva_1	2	N	1	46	1.145	40.139	148	194	2306
apr-23	ulva_1	3	N	1	89	1.174	75.809	205	294	2206
apr-23	ulva_2	1	Y	1	66	1.79	36.871	115	181	2319
apr-23	ulva_2	2	Y	1	33	1.958	16.768	150	183	2317
apr-23	ulva_2	3	Y	1	27	2.158	12.511	53	80	2420
feb-24	ulva_3	1	Y	1	42	1.651	25.44	68	110	2390
feb-24	ulva_3	2	Y	1	3	1.488	2.02	35	38	2462
feb-24	ulva_3	3	Y	1	7	1.205	5.81	10	17	2483
apr-24	ulva_4	1	N	24	89	1.9	46.93	223	312	2188
apr-24	ulva_4	2	N	24	49	1.92	25.57	223	272	2228
apr-24	ulva_4	3	N	24	50	5.05	9.88	223	273	2227
apr-24	ulva_5	1	Y	24	76	2.09	36.36	62	138	2362
apr-24	ulva_5	2	Y	24	123	2.61	47.13	62	185	2315
apr-24	ulva_5	3	Y	24	100	2.02	49.52	62	162	2338

PARALLEL ACTIVIETIES

EXPOSURE TO BIOBASED AND CONVENTIONAL MPS



The project was carried out at the **Mesocosm Facility at Umeå Marine Sciences Center** (Sweden).

Bioindicator organisms:

Gasterosteus aculeatus

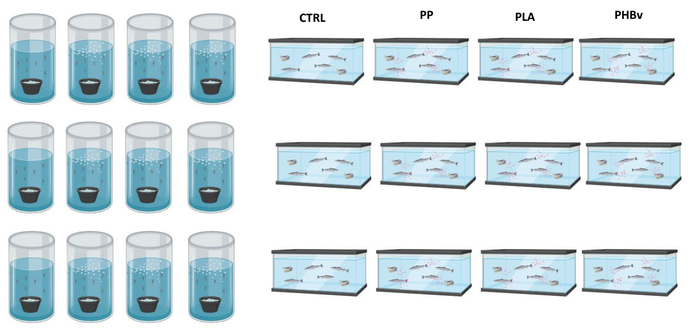
Macoma balthica

Clams and fish were exposed to 3 different types of microplastics: polypropylene (**PP**) , polylactic acid (**PLA**) and Poly(3-hydroxybutyrate-co-3-hydroxyvalerate (**PHBv**) for 21 days.

- For each treatment 3 mesocosms of 2000L were prepared, stickleback fish were exposed in parallel in 50L glass aquaria.
- Organisms were sampled after **7 (T2) and 21 (T6)** days of exposure.
- Microplastics **(<250µm**) were added at a concentration of **0.2 g/L.**

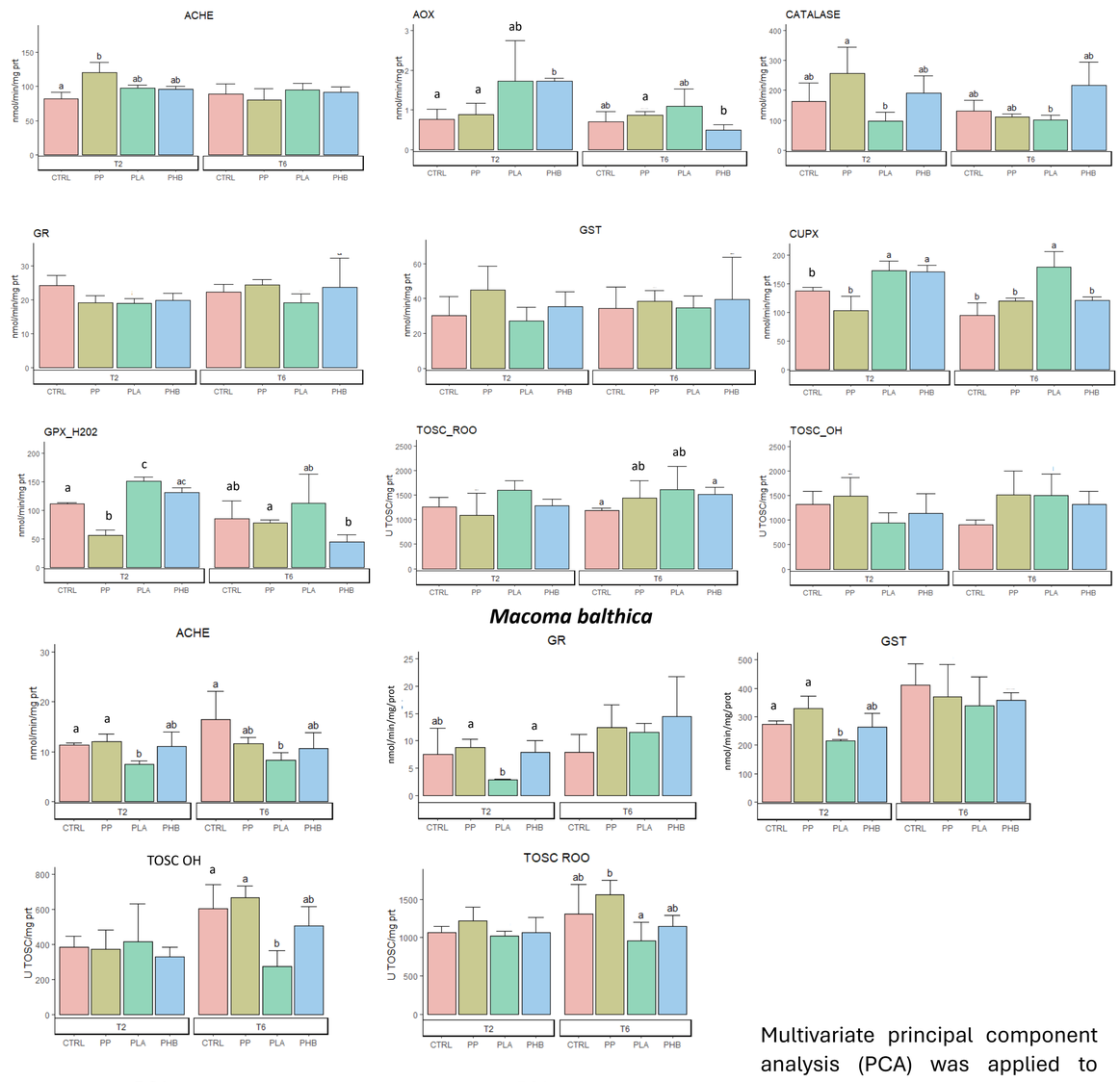
A wide battery of biochemical and cellular responses related to antioxidant system and oxidative damage, neurotoxicity and lipid peroxidation were investigated in target tissues (liver, gills, brain in fish and whole soft tissue in clams).

Bucket containing clams

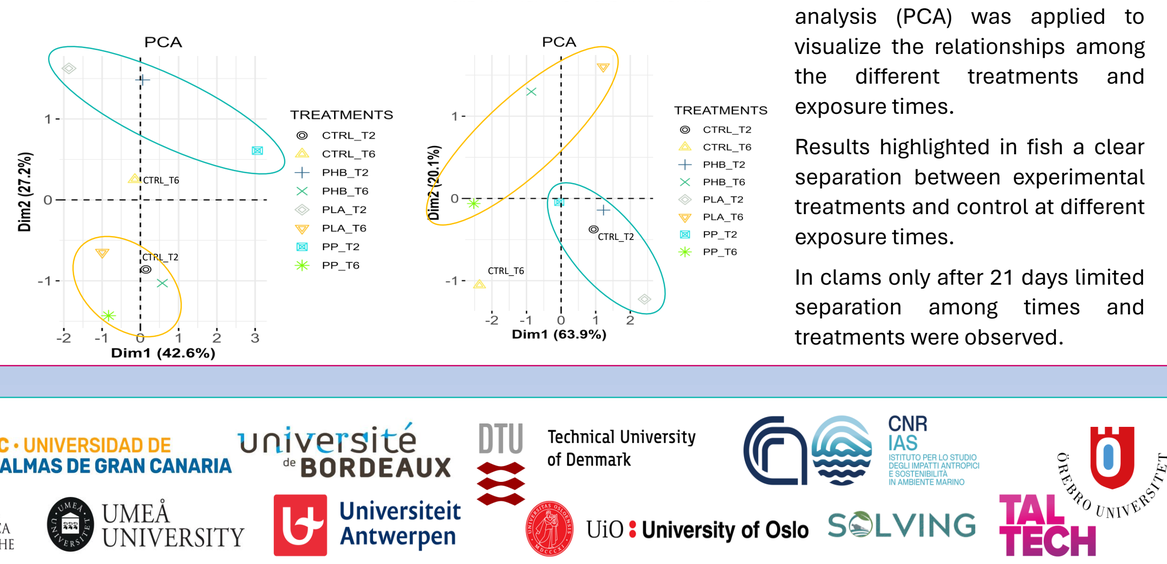


RESULTS

Gasterosteus aculeatus



Macoma balthica



Multivariate principal component analysis (PCA) was applied to visualize the relationships among the different treatments and exposure times.

Results highlighted in fish a clear separation between experimental treatments and control at different exposure times.

In clams only after 21 days limited separation among times and treatments were observed.

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