

ABSTRACT BOOK

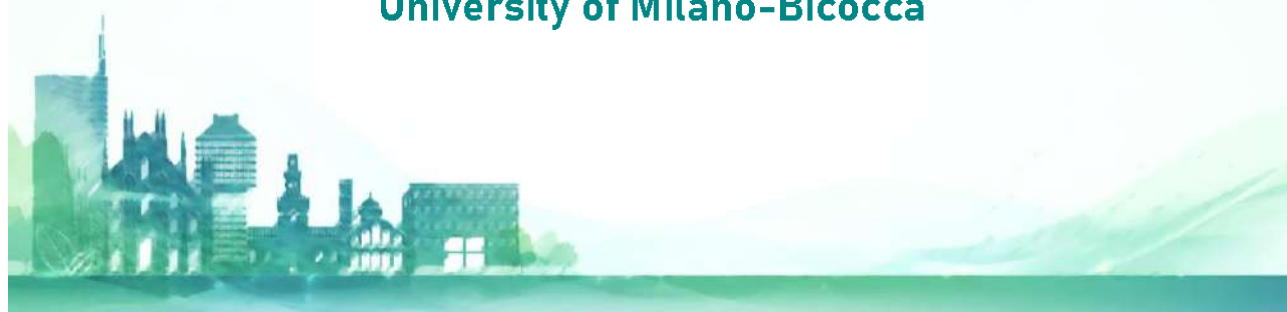
Plastics & Environment - 3rd Edition

Exploring Environmental, Sustainability and Planetary Health Dimensions



4-5th June 2026

University of Milano-Bicocca



SCIENTIFIC PROGRAM

DAY 1 -Thursday, 4th June 2026

Conference Program	
DAY 1 – 4 June 2026	
08:30 – 09:30	Open desk - Registration
09:30 – 11:30	OPENING WORKSHOP
	DESIGNING THE NEXT GENERATION OF SUSTAINABLE TEXTILES - <i>How innovation and regulation come together through Safe and Sustainable by Design</i> . Event included in the registration fee, sponsored by INTEGRANO e AICTC.
11:30 – 12:00	Welcome Coffee
12:00 – 12:15	Opening Ceremony Prof. Marco Orlandi - Rector of University of Milano-Bicocca; Prof. Matteo Colleoni - Rector's Delegate for Sustainability of University of Milano-Bicocca Prof. Elena Fabbri - Head of Department of Biological, Geological, and Environmental Sciences, University of Bologna Prof. Paride Mantecca - Conference Chair, University of Milano-Bicocca
12:15 - 13:30	Session 1 - Innovative monitoring methods and intra- and inter-environmental compartment fate of micro and nanoplastics (sponsored by IOPAN). <i>Chairs: Luca Ferrero (University of Milano-Bicocca), Zoè Iannuzzi (University of Lyon), Arto Hiltunen (University of Turku)</i>
12:15 – 12:45	Keynote Speaker: Francesca De Falco (University of Bayreuth) - <i>From Plastic Composition to Environmental Fate: Insights from Pyrolysis GC-MS</i>
12:45 – 13:05	Invited Speaker: Piotr Markuszewski (Institute of Oceanology, Polish Academy of Sciences) - <i>Inhalable microplastic across sea and atmosphere: release and uptake in function of ambient condition</i>
13:05 – 13:30	Session 1 - Selected Oral Presentations
	<i>Pietro Vahramian - Characterizing and counting micro and nanoplastics in complex liquids: applications of the SPES technique</i>
	<i>Alicia Checa Fernandez - Sampling and characterization of microplastics in drinking water treatment plants: towards a standardized and regulatory-compliant approach</i>
13:30 – 14:30	Light Lunch + Poster Session
14:30 – 15:45	Session 1 - Selected Oral Presentations
	<i>Valentina Balestra - First evidence of microplastic and microfibre pollution in cave dripping waters</i>
	<i>Cristina Cremonesi - Flocculation-Based Approaches for the Removal of Plastics in Wastewater Treatment Systems</i>
	<i>Giuseppe Suaria - Textile microfibers as stratigraphic markers in deep-Sea sediments</i>

	<i>Saima Shaukat- Microplastics in Lake Tanganyika: Unravelling spatial distribution in one of the world's largest and deepest freshwater lakes</i>
	<i>Marina Núñez Rubio -Textile Microplastic Emissions and Their Associated Organic Additives</i>
	<i>Cyril Charriaud - Laboratory-based feasibility studies demonstrate the potential for monitoring airborne microplastics using SwisensPoleno Jupiter</i>
15:45 – 17:45	Session 2 - Ecotoxicological and environmental impacts of plastics: emerging evidences and future challenges (sponsored by NanoTERRAE project). Chairs: Elena Fabbri (University of Bologna), Rossella Bengalli (University of Milano-Bicocca)
15:45– 16:15	Keynote Speaker: Violette Geissen (Wageningen University & Research) - <i>The hidden risk of agroplastics for food safety</i>
16:15 – 16:35	Invited Speaker: Veronica Nava (University of Milano-Bicocca) - <i>Reframing plastics in freshwater ecosystems: from contaminants to drivers of biogeochemical and ecological processes</i>
16:35 – 17:45	Session 2 – Selected Oral Presentations
	<i>Serena Ducoli - Influence of fragmentation techniques on the physicochemical properties and biotic aging of true-to-life microplastics</i>
	<i>Beatrice De Felice - An integrated approach to assess the toxicity of accelerated aged microplastics from conventional and biodegradable polymers in Daphnia magna</i>
	<i>Lorenzo Federico - Breaking plastic, breaking balance: multi-level effects of mulches on terrestrial isopods</i>
	<i>Francesca Garaventa - Impact of leachates from in-field collected plastics on aquatic organisms</i>
	<i>Jessica Zampolli - Genome-scale transcriptional and metabolic profiling uncovers Rhodococcus-mediated polyethylene biodegradation pathways</i>
17:45 – 18:05	Sponsor Presentations
	<i>Mattia Valentini (Thermo Fisher) - Seeing the Unseen: Microplastics by Acoustic Flow Cytometry</i>
18:05 – 19:30	Aperitivo

DAY 2 - Friday, 5th June 2026

Conference Program	
DAY 2 – 5 June 2026	
08:30 - 9:00	Open desk - Registration
09:00 - 10:45	Session 3 - Human exposure and adverse health effects of micro and nano plastics: unravelling the mysteries behind these ubiquitous threats (sponsored by POTENTIAL project). Chairs: Fabrizio Luppi (University of Milano-Bicocca), Rosalba Gornati (University of Insubria)
09:00 - 09:30	Keynote Speaker: Enrico Bergamaschi (University of Turin) - <i>An integrated approach to assess exposure and early health effects in human populations exposed to micro- and nano-plastics</i>
09:30 - 09:50	Invited Speaker: Paolo Bigini, Luisa Diomede (Mario Negri Institute for Pharmacological Research IRCCS) - <i>Development and standardization of a platform to evaluate the biological interaction and safety of micro-nanoplastics</i>
09:50 - 10:45	Session 3 - Selected Oral Presentations
	<i>Alberto Bernacchi - Microplastics interacts with the Intestinal Epithelial Barrier and disrupts permeability</i>
	<i>Maria Chiara Iachini - A multicellular 3D-airway assembloid model to assess the impact of micro- and nanoplastics on the human lung health: “life in plastic is not that fantastic”</i>
	<i>Ludovica Barone - Aged polystyrene leachates affect Human Dental Pulp Stem Cells</i>
	<i>Mayowa Olubukola Kolawole - Mechanical grinding of polypropylene bottles during pilot-scale recycling generates micro- and nanoplastic particles that can induce pro-inflammatory responses in macrophages</i>
10:45 - 11:15	Coffee break + Poster Session
11:15 - 13:05	Session 4 - Promoting Safe and Sustainable by Design, circularity and bioeconomy in polymers innovation (sponsored by INTEGRANO and REPLAY projects). Chairs: Paola Branduardi (University of Milano-Bicocca), Chiara Samorì (University of Bologna)
11:15 - 11:45	Keynote speaker: Andrea Amadei (European Commission, JRC) - <i>Plastic of today and tomorrow: production, consumption, circularity, and innovation at the science to policy interface</i>
11:45 - 12:05	Invited Speaker: Fabio Apone (Novamont) - <i>Industrial biotechnologies for circular economy models</i>
12:05 - 13:05	Session 4 - Selected Oral presentations
	<i>Marika Gargano - DIEGO: A Thermophilic PETase Enabling PET Upcycling for the Circular Bioeconomy</i>
	<i>Alex Pessina - An integrated biocatalytic platform for the circular valorization of PET</i>

	<i>Irene Tagliaro - PFAS-free biopolymer-based coatings with tailored wettability</i>
	<i>Stefano Fava - Polyhydroxybutyrate-based materials: characterisation and potential applications in agriculture</i>
	<i>Sara Borin - Evaluation of biobased carriers derived from agri-food waste for microbial biostimulant delivery in horticulture</i>
13:05 - 13:45	Sponsor Presentations
	<i>Gabriele Bulla (Jeol) - SEM Principles and main problems in plastic & polymers analysis</i>
	<i>Patrizio Barbini (Horiba) - Horiba Solutions for Microplastics: Systems & Strategies"</i>
13:45 - 14:45	Light Lunch + Poster Session
14:45 - 16:30	Session 5 - Plastics and climate-neutral cities. Rethinking practices, governance and politics for urban and environmental health. Chairs: Monica Bernardi (University of Milano-Bicocca), Alessandra Landi (University of Bologna)
14:45 - 15:15	Keynote Speaker: Luigi Pellizzoni (Scuola Normale Superiore) - <i>Beyond plastic futures</i>
15:15 - 15:35	Invited Speaker: Alberto Pizzocchero (Comune di Milano) - <i>New circular policies for the City of Milan</i>
15:35 - 15:55	Invited Speaker: Massimo Di Domenico (Confservizi Lombardia) - <i>Plastics and Climate-Neutral Cities: Governance, Circular Practices and the Role of Waste Utilities in Urban Environmental Health</i>
15:55 - 16:30	Session 5 - Selected Oral Presentations
	<i>Gianni Tartari - Microplastics in Lombardy's Waterbodies: An Environmental and Social Concern</i>
	<i>Emilio Cocco - Plastic Pollution and Artisanal Fisheries: A Comparative Analysis Between the Abruzzo Coast and Andaman Sea Communities in Thailand</i>
	<i>Mattia Lucertini - Urban Living Labs and Participatory Governance to Promote Alternative Circular Pathways for Plastics</i>
16:30 - 17:00	Closing remarks + Awards

POSTERS ON DISPLAY

Session 1 - Innovative monitoring methods and intra- and inter-environmental compartment fate of micro and nanoplastics			
Poster Nr°	Name	Family Name	Title
S1.P01	Guia	Morelli	Characterization and quantification of microplastic (MPs) in groundwaters on Pianosa Island (Tuscany, Italy)
S1.P02	Guia	Morelli	Abundance and distribution of microplastics and microfibers in water and riverbank sediments of the Arno River (Tuscany) and the impact of the urban area of Florence
S1.P03	Enmanuel	Cruz Muñoz	A Rapid Monitoring Protocol for Complex Microplastic Mixtures: Combining Portable NIR Spectroscopy with Machine Learning
S1.P04	Zoé	Iannuzzi	Identifying sources of microplastics in a city: a case study of an industrial catchment
S1.P05	Francesca	Pittino	Polyethylene terephthalate weathering in cryoconite holes
S1.P06	Léa	Davy	Model microplastics for studying fate and interactions in urban stormwater runoff
S1.P07	Elena	Tortarolo	Quantification and Characterization of Fibrous Microplastic Release from Synthetic Textiles: Preliminary Results of the SUMMIT Project
S1.P08	Mohammed Monsoor	Shaik	Controlled Generation of Representative PET Micro- and Nanoplastics by Ethylene Glycol Fragmentation for Environmental and Toxicological Studies
S1.P09	Sofia	Lorenzini	Fabrication of PET nanoplastics and their interactions with chlorpyrifos and bisphenol A
S1.P10	Mara	Putzu	Towards validated and standardised workflows for microplastic quantification
S1.P11	Korinna	Altmann	Reference materials for precise and accurate microplastic results
S1.P12	Tommaso	Gatti	Microfibers in drinking water, a new analytical challenge: detection of disinfection by-products of microfibers
S1.P13	Silvia	Lupato	A Dye-Based Approach for Quick Synthetic Microfibres Characterisation in Water Samples
S1.P14	Stefano	Fava	Assessment of hydrothermal carbonization (HTC) efficiency for microplastic removal from sewage sludge
S1.P15	Beatrice	Dal Pio Luogo	From wash to wear: a cross-value chain assessment of textile and washing process variables for sustainable, system-level design guidelines
S1.P16	Giovanni	Dolci	Analysis and characterisation of microplastics in composts

S1.P17	Mattia	Alessi	Microplastics in inflowing streams of Lake Orta (Northern Italy)
S1.P18	Camilla	Fantasia	Integrated analysis of microplastics in marine sediments and air involving GC-MS-pyrolysis and Agilent LDIR spectroscopy with a single shared sample preparation workflow.
S1.P19	Davide	Riseri	Detecting the route of Mediterranean Litter, tracing back natural volcanic pumice
S1.P20	Giorgia	Dassiè	Microplastics release from UHMWPE ski bases: tribometer simulation and spectroscopic analysis
S1.P21	Anna	Waleczek	Microplastics at the Air–Sea Interface: Comparative Observations from the Maldives and the North Atlantic

Session 2 - Ecotoxicological and environmental impacts of plastics: emerging evidences and future challenges

Poster Nr°	Name	Family Name	Title
S2.P01	Giada	Caorsi	Beyond pure polymer: the Role of Additives in ecotoxicity of PEG-based Pharmaceuticals on <i>Danio rerio</i>
S2.P02	Sonia	Tassone	Impact of Polyethylene Terephthalate Microplastics on Rumen Activity
S2.P03	Francesco Alessandro	Palermo	Microplastics as vectors of organic contaminants accumulated in aquatic environments: chemical characterization and endocrine–metabolic effects in fish
S2.P04	Riccardo	Sbarberi	Multigenerational effects of fossil-based versus recycled nylon on benthic freshwater macroinvertebrates
S2.P05	Paola	Valbonesi	Biological effects of cellulose-based bioplastics leachates on adults <i>Mytilus galloprovincialis</i>
S2.P06	Serena	Scala	Chemical characterization of leachates from cellulose-based bioplastics and their biological effects on larvae of <i>Mytilus galloprovincialis</i>
S2.P07	Simona	Mondellini	Exposure to polyethylene terephthalate (PET) nanoplastics induced oxidative stress and altered swimming behaviour in <i>Daphnia magna</i>
S2.P08	Enrico	Stuani	From Material to Organism: A Comprehensive Pipeline for “True-to-Life” Micro- and Nanoplastics Characterization and Biological Interaction
S2.P09	Manon	Auguste	Leachates from paper-based bioplastic items induce shifts in microbiome composition of different tissues of marine mussels
S2.P10	Teresa	Balbi	Impact of leachates from paper-based bioplastic items on immune function and oxidative stress biomarkers of marine mussels

S2.P11	Andrea	Masseroni	Exploring the effects of microplastic leachates on <i>Porcellionides pruinosus</i> and <i>Folsomia candida</i>
S2.P12	Simona	Ortelli	Colloidal characterization of bio/eco-corona formation on nanoplastics
S2.P13	Shabab	Hussain	Impact of Microplastics From Face Masks On Zebrafish Embryo Development And Toxicity
S2.P14	Alessia	Dicesare	Investigating Roadside Soil Microbiomes: Metagenomic Analyses to Identify Taxa Driving Rubber Degradation
S2.P15	Luis Fernando	Zambrano Mite	Combined Effects of Microplastic Contamination and Phosphorus Deficiency on Tomato Rhizosphere Dynamics
S2.P16	Federico	Cerri	Plastic pollution in Maldivian mangroves: emerging evidence of macroplastic accumulation

Session 3 - Human exposure and adverse health effects of micro and nanoplastics: unravelling the mysteries behind these ubiquitous threats

Poster Nr°	Name	Family Name	Title
S3.P01	Martina	Motto	Impacts of Micro and Nano Plastics on Brain and Intestine Inflammation Through [18F] FDG PET/CT Imaging and Immunohistochemistry
S3.P02	Sara	Bozzer	Nanoscale membrane disruptions induced by polymeric nanoplastics in human umbilical vein endothelial cells (HUVECs) revealed by synchrotron nano-XRF imaging
S3.P03	Matilda	Pedrinazzi	Development of a dynamic 3D in vitro model of the neurovascular unit to investigate micro/nano-plastics neurotoxicity
S3.P04	Rossella Daniela	Bengalli	Hazard assessment of advanced nanotextiles in a safe and sustainable by design perspective
S3.P05	Utkarsh	Sharma	Human Exposure to Micro and Nano- plastics and Risk Assessment
S3.P06	Martina	Broggiato	Immune responses of human monocytes to pristine and UV-aged micro- and nanoplastics
S3.P07	Gaia	Panzeri	Assessing The Interaction Between Micro- And Nanoplastics (Mnps) And Human Gut Microbiota
S3.P08	Ada	De Luigi	The surface charge of plastic nanoparticles plays a key role in their interaction with biological matrices
S3.P09	Matilda	Porro	Analysis of production and characterization of PLA micro and nanoplastics using ball-milling
S3.P10	Anna	Baroni	The impact of polystyrene nanoplastics on microglial function: Preliminary evidence of neurotoxicity, oxidative stress and impaired neurotransmission

Session 4 - Promoting Safe and Sustainable by Design, circularity and bioeconomy in polymers innovation

Poster Nr°	Name	Family Name	Title
S4.P01	Filipa	Lima	System-level assessment of additives in recyclable polymer value chains using material flow analysis
S4.P02	Muhammad	Farhan	Comprehensive Characterization of Novel Ceramic Filler (Black Obsidian) Reinforced Polymer Composites: A Safe and Sustainable by Design (SSbD) Perspective
S4.P03	Laura	Badalucco	PLEIADES: Design-Driven Innovation for Sustainable Polymer Products
S4.P04	Yang	Wang	Rapid Enzymatic Screening of Polymer Biodegradability for Sustainable Packaging Applications
S4.P05	Mina	sabahi lotfabadi	Testing durability of next-generation marine composites on a racing yacht: bridging performance and circularity
S4.P06	Paola	Branduardi	Insights and roadblocks in terephthalic acid upcycling with <i>Saccharomyces cerevisiae</i>
S4.P07	Fiorella	Masotti	Microbial upcycling of terephthalic acid into protocatechuic acid via optimized <i>Pseudomonas putida</i> fermentation
S4.P08	Riccardo	Milanesi	Optimization of ethylene glycol upcycling to glycolic acid through yeast biodiversity and process conditions
S4.P09	Leonardo Maria	Colnaghi	Production of microbial oils by oleaginous yeasts for bioplastic applications
S4.P10	Silvia	Galafassi	From source to resource: recovery and biotechnological valorisation of textile microfibres from domestic appliances
S4.P11	Chiara	Pizzigoni	Hydrophilic polysaccharide coatings for ice adhesion reduction
S4.P12	Rosa	Zullo	From Microplastic Hotspots to Solutions: Leveraging Wastewater Treatment Plants for PET Valorization and Emission Reduction
S4.P13	Kacper	Pobłocki	Options for riverine plastic waste collected in Motława river (Poland)
S4.P14	Roberto	Pelusio	Innovative Low-Friction Coatings for Synthetic Fabrics: Preventing Microplastic Pollution at the Source
S4.P15	Andrea	Vezzulli	The ProPla project: A Patent Landscape Analysis of the main technological trends for the microPET conversion into value-added products
S4.P16	Gaia	Pilerci	Metabolic engineering and in silico modelling of ethylene glycol assimilation in <i>Saccharomyces cerevisiae</i> .
S4.P17	Ananth	Selvan	Safe and Sustainable by Design Approach for Lapis Lazuli Fine Stone Filler Toward Advanced Polymer Composite Applications

Session 5 - Climate-neutral cities and plastic. Rethinking practices, governance and politics for urban and environmental health

Poster Nr°	Name	Family Name	Title
S5.01	Aurora	Nurce	Defining Plastic Pollution: Framing Struggles and Regulatory Outcomes in the Global Plastics Treaty Negotiations
S5.02	Eleonora	Bechis	Energy Transition and Environmental Violence in Sacrifice Zones. The Case of Spinetta Marengo Chemical Complex, Alessandria
S5.03	Senzio Sergio	D'Agata	Recycling as a Political Artefact: When the Numbers Tell a Different Story
S5.04	Marta	Caria	Do Urban Policies Really Reduce Plastic Waste? Evidence and Limits from European Cities
S5.05	Selene	Tondini	Plastic Transition: New Practices, Negotiation Processes and Resistances in Local Contexts of Circular Innovation
S5.06	Fabiola	Fasolo	Great 'Plastic Free': A Parish Summer Programme as a Non-Conventional Channel for Microplastics Awareness
S5.07	Valentina	Pantaleo	Migrants, Ecomafia Processes and De-territorial transformation in Ragusa (Sicily)

Session 1 – “Innovative monitoring methods and intra- and inter- environmental compartment fate of micro and nanoplastics”

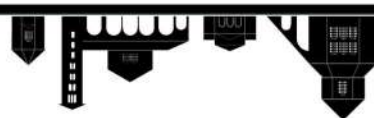


Oral Presentations





Plastics & Environment, 4-5th June 2026, Milan

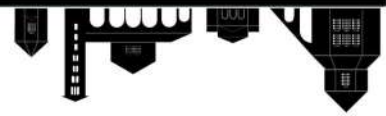


Keynote Speaker: Francesca De Falco - University of Bayreuth

Title: From Plastic Composition to Environmental Fate: Insights from Pyrolysis GC-MS

Abstract:

Understanding the environmental fate of plastics requires detailed knowledge of their chemical composition, encompassing both polymer matrices and associated additives. Processes such as degradation, additive leaching, and the release of micro and nanoplastics are central to how plastics behave in the environment. This keynote presents the application of pyrolysis coupled with gas chromatography–mass spectrometry (Py-GC–MS) as a powerful tool to characterize plastic materials and to link their molecular markers to degradation pathways and environmental behaviour. Through selected case studies on plastic products, including agricultural mulch films, wet wipes, and textiles, Py-GC-MS is used to identify polymers and additives and to monitor their transformation over time under laboratory or field exposure conditions. This approach highlights the potential of Py-GC-MS not only for detailed material characterization but also as a complementary method for unravelling the mechanisms governing plastic persistence and fate in the environment.



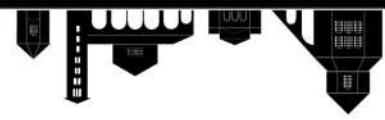
Invited Speaker: Piotr Markuszewski - Institute of Oceanology Polish Academy of Sciences

Title: Inhalable microplastic across sea and atmosphere: release and uptake in function of ambient condition

Abstract:

Microplastics are now recognised as contaminants of both the marine environment and the atmosphere, yet the processes governing their exchange across the air–sea interface remain poorly understood. This presentation will showcase results from field studies conducted in the Baltic Sea and the northern Indian Ocean, with a focus on how ambient meteorological and oceanographic conditions control the occurrence, properties, transport, release, and uptake of airborne and marine microplastics. The talk will highlight how microplastic concentrations, composition, and size distributions change across contrasting environments and under different forcing conditions. Results from the Baltic Sea reveal a strong coupling between the sea surface and the atmosphere, with evidence of both marine emission and atmospheric transport of microplastics. Observations collected during major winter storms in 2022 further demonstrate the importance of hydrodynamic forcing for the redistribution of microplastics within the water column. In contrast, measurements from the Maldives indicate weaker air–sea coupling during the observation period, with airborne microplastics linked more closely to regional polluted air-mass transport than to local marine emissions.

By combining microplastic measurements with atmospheric aerosol observations, this presentation will underline the importance of an interdisciplinary air–sea interaction framework for understanding the environmental fate of microplastics. More broadly, it will demonstrate the research potential of integrating aerosol physics, marine observations, and process-based interpretation to investigate emerging pollutants in the coupled ocean–atmosphere system.



Characterizing and counting micro and nanoplastics in complex liquids: applications of the SPES technique

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Keywords: particle analysis, size distribution, microplastics

Associated conference sessions: 1, 2

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The presence of micro and nano-plastics in environmental liquids, their release from different materials and their bioaccumulation are a growing concern. Measuring their presence in complex matrices and liquids is a challenging experimental effort, as their presence is often hidden by other particles, like impurities and organic materials.

In this presentation we will introduce a novel analytical technology named SPES (Potenza, 2015; Villa, 2016), Single Particle Extinction and Scattering, that addresses these issues by performing a multiparametric, calibration-free optical measurement of particles in liquid. The SPES method measures several optical properties at the single-particle level – extinction cross section, polarizability and light

scattered at 90 degrees – and it allows to retrieve particle's size, refractive index, absolute numerical concentration, and infer particle's shape and internal structure. Moreover, the multiparametric data gives an effective way to separate individual particle populations in heterogeneous samples and mixtures.

This methodology is particularly effective in overcoming the challenges posed by the heterogeneity and diverse optical properties of particles in environmental and biological samples. We will present practical examples of the SPES methods applied to:

1. The quantification and characterisation of submicron particles released by polypropylene containers for alimentary use upon overheating (Pallavera, 2024)
2. The characterisation and tracking over time of polystyrene and poly(lactic-co-glycolic acid) (PLGA) nanoparticles in murine blood and serum (Sanvito, 2017)

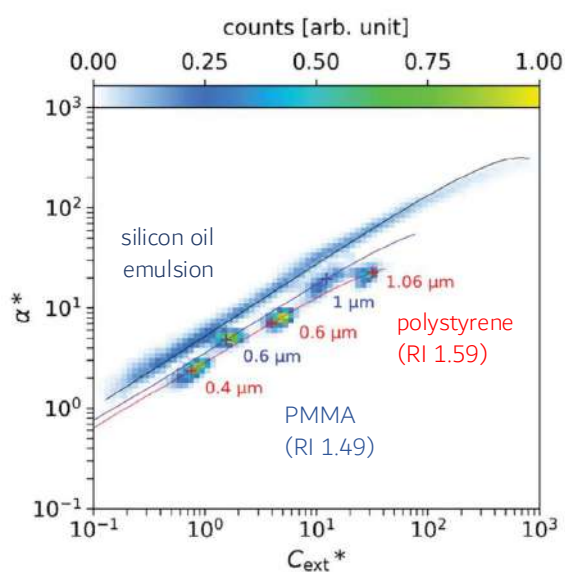
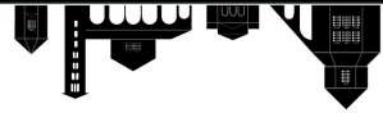


Figure 1: SPES can distinguish individual populations of polystyrene and PMMA spherical microplastics in an heterogeneous sample. Image reproduced from (Pallavera, 2024)

References

- Potenza, M. A., Sanvito, T., and Pullia, A. (2015) *Aip Advances*, 5(11)
- Villa, S., Sanvito, T., Paroli, B., Pullia, A., Delmonte, B. and Potenza, M. A. C. (2016) *Journal of Applied Physics*, 119(22)
- Pallavera, M., Sanvito, T., Cremonesi, L., Artoni, C., Falqui, A. and Potenza, M.A. (2024) *Particle & Particle Systems Characterization*, 41(12), p.2400029
- Sanvito, T., Bigini, P., Cavanna, M. V., Fiordaliso, F., Violatto, M. B., Talamini, L., ... and Potenza, M. A. (2017) *Nanomedicine: Nanotechnology, Biology and Medicine*, 13(8), 2597-2603



Sampling and characterization of microplastics in drinking water treatment plants: towards a standardized and regulatory-compliant approach

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Keywords: microplastics; self-designed automatic sampling; regulatory compliance; environmental monitoring; method standardization.

Associated conference sessions: 1

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Water is a major pathway for microplastics (MP) dispersion, and drinking water treatment plants, which process large volumes daily, act as key receptors of these contaminants. This has raised public and scientific concern and highlighted the need for monitoring to assess risks and guide mitigation.

The Delegated Decision (EU) 2024/1441 defines standardized procedures for MP sampling and analysis in drinking water, including 1000 L representative sampling via a four-stage filtration sequence. Accordingly, a harmonized methodology was developed and validated to test the EU framework under real operating conditions. The workflow integrates automated high-volume sampling, controlled pre-treatment, filtration, and μ -Raman polymer characterization (Figure 1).

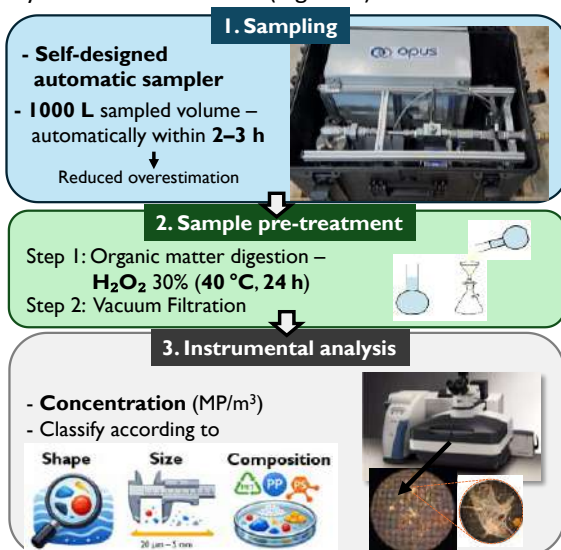


Figure 1. Developed methodology for MPs analysis in accordance with the EU 2024 Delegated Decision.

In particular, an innovative portable automated sampler was designed by Acea Infrastructure,

engineered and built by Opus Automazione SpA, and submitted for patent registration. The sampler enables the collection of 1000 L samples at a controlled flow rate, improving representativeness and offering a key advantage over existing technologies by markedly reducing contamination risks from MP generated or introduced during sampling. This enhances measurement reliability while ensuring full regulatory compliance. Its modular configuration and automated management support deployment in multiple monitoring contexts, including distribution networks, industrial environments, and surface water bodies.

Subsequently, the removable filters undergo a pre-treatment (30% H_2O_2 , 40 °C, 24 h), effectively removing organic matter without affecting polymer integrity. Vacuum microfiltration on 5 μ m silica membranes is then applied, and μ -Raman spectroscopy enables reliable polymer-specific identification.

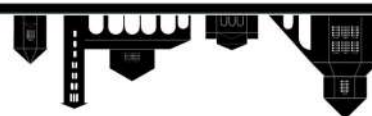
The developed methodology was validated by Acea Infrastructure in full-scale DWTPs, confirming its suitability for routine monitoring. Low MP concentrations (<50 MP/m³) were detected in treated water and were mainly related to polymers belonging to priority lists, such as polyethylene (PE). Particles were largely fragment-shaped, with size distributions concentrated in the 20–100 μ m range.

Overall, the proposed approach supports reproducible, standardized, and regulation-compliant monitoring of MP in drinking water systems, with future work aimed at testing its performance across additional operational and environmental contexts.

This work was supported by Acea Group.

References

EU (2024). Commission Delegated Decision (EU) 2024/1441 on the methodology for measuring microplastics in drinking water. Off. J. Eur. Union



First evidence of microplastic and microfibre pollution in cave dripping waters

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Keywords: microplastics, microfibres, pollution, dripping waters, caves.

Associated conference sessions: 1

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Microplastics (MPs) are pervasive contaminants in terrestrial and aquatic environments worldwide, owing to their intrinsic properties that favour persistence and widespread distribution. Recent studies have emphasized the importance of including also natural and regenerated fibres of anthropogenic origin in environmental assessments. Synthetic, regenerated and natural fibres are commonly called microfibre (MFs) in environmental sciences.

Karst environments, despite their significant ecological and hydrological roles, received limited scientific attention on this topic. Due to their highly permeable and interconnected nature, karst subterranean systems are particularly susceptible to pollutants.

In this preliminary investigation we analysed dripping waters from Torri di Slivia cave, Friuli-Venezia-Giulia Region, NE Italy. For the first time, the occurrence of MPs and other anthropogenic microparticles (AMPs), including MFs, in cave dripping waters were reported, highlighting the indirect influence of surface human activities on subterranean aquatic systems. AMPs were quantified and characterized via microscopy and spectroscopy.

The 80.5% of the analysed AMPs were cellulosic and 81.6% fibres. Synthetic materials constituted only 19.5%. MP concentrations ranged from 0 to 23 MPs/L and were polyethylene terephthalate (PET) and polyurethane (PU). All MPs were fragments, except for a single PET fibre. Particles smaller than 1 mm represented the majority (89.3%) of the observed AMPs, with the most frequent size class ranging between 0.10 and 0.49 mm (51.5%).

Potential sources of contamination in cave dripping waters may include waste disposal in sinkholes, littering, roads and railways, and

anthropogenic activities occurring at the surface. These results highlight MPs and other AMP pollution exists in cave dripping waters, impacting water resources, habitats and species.

More comprehensive and multidisciplinary monitoring are needed, considering surface and subterranean connections in karst areas, aiming at conservation purposes. Promoting collaborations with show caves and cavers can be instrumental in pilot studies and acquiring new and valuable data.

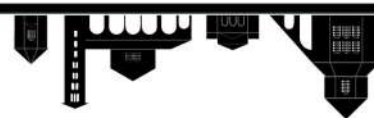


Figure 1. Dripping water sampling in Torri di Slivia cave, NE Italy

This research is part of the PhD thesis of Valentina Balestra (Balestra, 2026).

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Flocculation-Based Approaches for the Removal of Plastics in Wastewater Treatment Systems

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Keywords: Wastewater treatment plants, plastics pollution, aquatic environments.

Associated conference sessions: 1

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The continuous increase in plastic production and use, along with their subsequent release into natural ecosystems, represents a significant concern for both environmental and human health. Wastewater Treatment Plants (WWTPs) have been identified as one of the major pathways through which plastics enter aquatic environments (Prata, 2018). Although several studies have demonstrated the effectiveness of coagulants and flocculants in removing plastics under laboratory conditions, their practical application in WWTPs remains largely unexplored (Ma et al., 2019; Zhang et al., 2022). This study evaluated the effectiveness of different commercial polymer-based flocculants, both synthetic and natural, in reducing plastic concentrations in wastewater. Jar tests were performed using wastewater samples collected directly from a treatment plant, to which four commercial flocculants (two bio-based and two polyacrylamide-based) were added at three concentrations close to the dosage typically recommended for suspended solids removal (0.10 g/L). These tests were conducted in combination with artificially prepared plastic mixtures, with a particular focus on fibers, which represent the most prevalent form of microplastics in aquatic ecosystems, approximately 35% (Mishra et al., 2020). Plastic removal efficiency was quantified by comparing the number of particles remaining in suspension after treatment with the initial concentration. In addition, to ensure the potential applicability of the tested flocculants, several chemical parameters were monitored to assess compliance with regulatory requirements (European Directive (EU) 2024/3019). The results demonstrated that the use of coagulants, chemical agents that promote particle aggregation, was necessary to meet the chemical standards set by the Directive. Among the tested coagulants, polyaluminum chloride (PAC), applied at a concentration of 0.08 g/L,

showed the best performance while complying with regulatory limits. Flocculation tests conducted with this optimal PAC dosage showed comparable plastic removal efficiencies, achieving $96.25\% \pm 0.72$ for bio-based polymers and $99.58\% \pm 1.65$ for polyacrylamide-based polymers. These findings highlight the potential applicability of flocculation-based treatments for plastic mitigation in industrial WWTPs and suggest that natural flocculants may represent a more sustainable alternative to synthetic polymers, contributing to improved environmental safety in wastewater treatment processes.

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Textile microfibers as stratigraphic markers in deep-Sea sediments

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Keywords: textile microfibers, deep-sea sediments, anthropogenic pollution, stratigraphic markers

Associated conference session: 1

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The deep sea, once considered pristine, is now recognized as a major sink for anthropogenic debris, including textile-derived microfibers. Because of their persistence and exclusively human origin, microfibers have emerged as promising stratigraphic markers of the Anthropocene. This study investigates the vertical distribution, material composition, and temporal trends of microfibers preserved in deep-sea sedimentary records, assessing their value as indicators of historical human impact. A high-resolution sediment core spanning more than a century of deposition was retrieved from 368 m depth in the central Mediterranean Sea using an oceanic box corer equipped with a stainless-steel liner. Sediments were sectioned at sub-centimeter resolution, and fibers were extracted via ZnCl₂ density separation, quantified under stereomicroscopy, and chemically identified using micro-Fourier Transform Infrared spectroscopy (μ FTIR). Fiber abundance was normalized to sediment dry weight and converted to depositional age using a sedimentation rate of 0.24 cm yr⁻¹.

More than 1,200 microfibers were identified across the core, revealing a clear and non-random stratification pattern. Fiber concentrations increased markedly toward surface layers and showed a strong positive correlation with estimated deposition year (Spearman's $\rho = 0.93$, $p < 0.001$), consistent with regional and global trends in textile and plastic production. Cellulose-based fibers (man-made cellulosic, natural, and animal) dominated the record (83.7%), but synthetic polymers (PET, PE and PP; 12.7%) were detected exclusively in layers deposited after the 1960s, coinciding with the global expansion of synthetic textiles and plastics (Matsuguma et al., 2017; Simon-Sánchez et al., 2022). Procedural blanks contained significantly fewer fibers than environmental samples (Wilcoxon test, $p < 0.01$), validating sample integrity.

These results confirm that microfibers are preserved in deep-sea sediments with sufficient stratigraphic coherence to trace the temporal evolution of anthropogenic pollution, in agreement with previous observations from deep Mediterranean and global sedimentary archives (Sánchez-Vidal et al., 2018). Beyond their stratigraphic value, the persistent accumulation of textile microfibers highlights ongoing and long-term exposure risks for benthic ecosystems. The deep sea thus represents not only a final sink for human-made debris, but also a high-resolution archive for reconstructing the chronology and ecological legacy of human activity.

Acknowledgements

We thank the captain and crew of R/V *Gaia Blu* and scientific personnel involved in the PIONEER cruise. This research was funded under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.1, Call for Tender No. 104 published on 2.2.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union–NextGenerationEU–Project Title MICROBEEF “MICROplastic effects on marine Benthic Ecosystems Functioning” (Grant Agreement No. 2022X4WLEK)

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Microplastics in Lake Tanganyika: Unraveling spatial distribution in one of the world's largest and deepest freshwater lakes

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Associated conference sessions: 1

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Microplastics (MPs) are emerging global pollutants (Nava *et al.*, 2023), but remain poorly studied in tropical African freshwater systems. Lake Tanganyika, the world's longest (673 km) and second deepest (1,470 m) freshwater lake, holds 17% of global surface freshwater and supports rich biodiversity and millions of livelihoods (Plisnier *et al.*, 2018). Despite its importance, research on MPs in this region is still limited.

This study presents the first large-scale assessment of MP contamination in Lake Tanganyika. We conducted a cross-site assessment of MP abundance based on surface water sampling at 10 geographically distinct locations during the dry season. Samples were collected using manta nets with flow meters, filtered through a 250 µm sieve, treated with H₂O₂ to remove organic matter, and examined under a dissecting microscope. Suspected MPs were initially identified based on morphological characteristics and subsequently confirmed using Raman spectroscopy, with particle size, shape, and colour recorded.

Microplastics were detected at all sampling sites, indicating widespread contamination across the lake, though their distribution was uneven. Higher concentrations occurred near urbanized and river-influenced areas such as the Uvira bay in the Democratic Republic of Congo and the Rusizi River inlet, while MPs were also present in remote and protected zones, suggesting the role of lake-scale hydrodynamic processes in their transport. Fragments and fibres were the dominant forms, with polypropylene (PP)

and polyethylene terephthalate (PET) as the main polymers.

Overall, the results indicate clear spatial variation in microplastic distribution, influenced by both anthropogenic activities and hydrodynamic processes. Future wet-season sampling will further refine understanding of temporal dynamics. These findings highlight the importance of including large tropical lakes, particularly in Africa, in global monitoring and mitigation efforts.

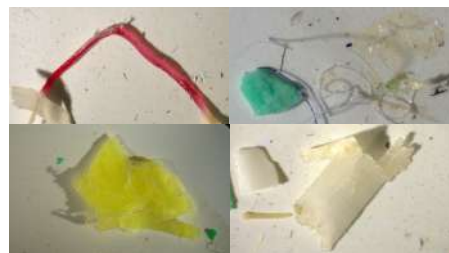


Figure 1. Identified microplastic particles (fibres & fragments).

This research was funded by the European Union under the TAKIWAMA project, implemented by Enabel, the Belgian Agency for International Cooperation.

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Textile Microplastic Emissions and Their Associated Organic Additives

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Keywords: Textile microplastics, Airborne pollution, Plastic additives, FTIR, HPLC-MS.

Associated conference sessions: 1

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Airborne microplastics (MPs) are recognized as an emerging inhalation hazard (Gan *et al.*, 2025). Textiles are a major source, releasing MPs during their production, use, drying and disposal (European Environment Agency, 2022). In addition, textiles often contain additives, such as PFAS or phthalates, increasing human exposure to complex chemical mixtures (Chen *et al.*, 2022). This study characterizes airborne MP release under controlled airflow conditions and evaluates the presence of chemical additives across a range of textile types, providing evidence to identify fabrics with lower emissions and chemical profiles.

Textiles of different polymer types (polyester, acrylic, polyamide, viscose), color, and texture were characterized by FTIR and microscopy. A total of 16 samples were placed in a custom-built chamber operating at constant airflow. Released MPs were captured on meshes, quantified, measured, and weighted. Additives were extracted using a Solid-Liquid extraction (with methanol, acetonitrile, and hexane) through sequential ultrasonic baths, followed by nitrogen-assisted solvent evaporation and reconstitution prior to HPLC-Orbitrap MS analysis. Analysis is currently ongoing and will be presented at the conference.



Figure 1. Experimental workflow.

A total of 87.5% of all tested textiles released MPs. Release rates varied by polymer and texture, with polyester releasing the most (7.7 MPs/m²), followed by acrylic (1.51 MPs/m²) and polyamide (0.61 MPs/m²),

while viscose released the lowest (0.21 MPs/m²). Among textures, satin (17.6 MPs/m²) and fur fabric (7 MPs/m²) showed the highest releases. Daily human exposure to MPs for each textile was estimated with default inhalation rates for residential and occupational scenarios (U.S. Environmental Protection Agency, 2009), with values up to 13 MPs/day for residential populations and 6 MPs/day for occupational environments. Preliminary additive analyses reveal the presence of several additives, suggesting that airborne MPs act as carriers of hazardous chemicals. These findings reveal textile categories with different particle and additive emissions, enabling informed identification of the most hazardous textiles from an exposure perspective.

This work was supported by PID2024-155145OA-C22 and RyC2021-034953-I from the European Union "NextGenerationEU"/PRTR.

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Laboratory-based feasibility studies demonstrate the potential for monitoring airborne microplastics using SwisensPoleno Jupiter

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Keywords: real-time, microplastics, monitoring, air-flow cytometer

Associated conference sessions: 1

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Global plastic production and poor waste management cause microplastic pollution (particles 1–1000 μm , primary or secondary). Micro plastic (MP) can persist and spread for years. Due to their size, shape, and low density, these particles can be transported through the atmosphere like coarse dust, reaching remote and pristine regions and posing risks to ecosystems and human health.

For example, tyre wear particles (TWP) should be monitored due to their major role in MP pollution and associated risks to ecosystems and health. Tyre abrasion contributes to 5–30% of road transport particulate matter (PM) emissions (Giechaskiel et al. 2024).

Detecting airborne microplastics is difficult because most methods are offline, resource-intensive, and cannot provide continuous quantitative monitoring.

(Beres et al. 2024) investigated the feasibility of automatic monitoring airborne micro plastic (MP) with the air-flow cytometry-based instrument SwisensPoleno Jupiter. Based on this system, which combines holographic imaging (Figure 1 above) and fluorescence spectral measurements with a machine-learning classifier they could accurately identify five common microplastic polymer types and distinguish them from similar coarse aerosol particles (e.g., mineral dust, pollen, water droplets) in controlled lab conditions. Model performance improved when combining single-particle holograms with relative fluorescence data, and all tested MPs produced detectable fluorescence within the instrument's range (Figure 1 below).

The results of the feasibility study on tire wear presented by (Schwendimann 2025) showed that the tyre wear generated using a DLR test setup produces particles up to 100 μm in length, which can be measured (Figure 1 above).

Further work is needed to assess performance with more complex samples (e.g., fibers, weathered MPs,

additives) and additional autofluorescent aerosols to validate ambient, real-world monitoring applicability.

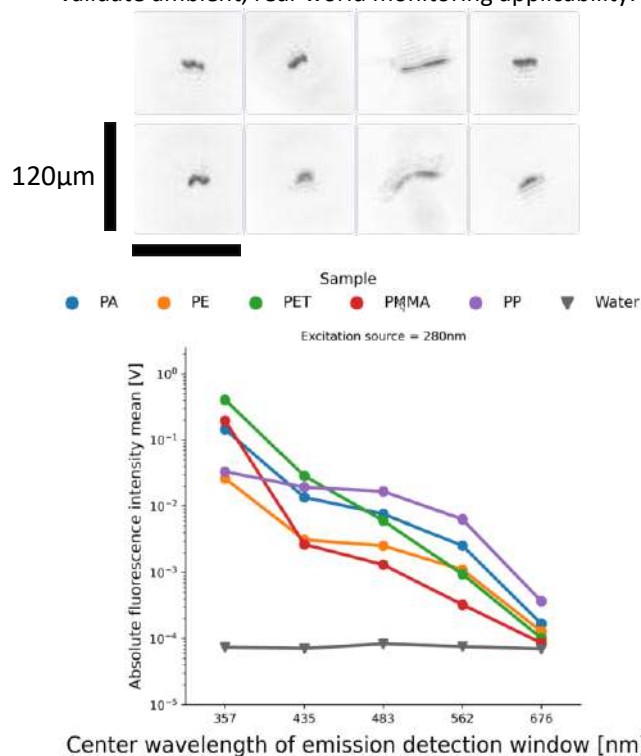


Figure 1. Above view: Holographic images of tyre wear particles measured in flight with SwisensPoleno
Below: Absolute spectral autofluorescence signals from different types of microplastics measured in flight with SwisensPoleno

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Schwendimann et al., ETH Nanoparticle Conference 2025, Session 10, Brake and tyre wear particles, Part 2

Session 1 – “Innovative monitoring methods and intra- and inter- environmental compartment fate of micro and nanoplastics”



Poster





Characterization and quantification of microplastic (MPs) in groundwaters on Pianosa Island (Tuscany, Italy)

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Keywords: groundwaters, island aquifer, microplastics, conservation, environmental contamination.

Associated conference sessions: 1, 2

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Groundwater represents the most important freshwater resource on islands. Microplastics (MPs) penetration into groundwater bodies (via atmosphere, infiltrations, or anthropic contribution) affect aquifers quality and biodiversity. Investigation of microplastic (MPs) in groundwater on islands is scarce. This work quantified for the first time MPs pollution in the groundwater of Pianosa Island (Italy), a 10 km² island within the Tuscan Archipelago National Park, a climatic and environmental hotspot in the Mediterranean Sea. The island is formed by Neogenic-Quaternary sedimentary rocks, with superficial calcarenite deposited above marl and clayey marl with sandstone and conglomerate layers. Water samples from eight wells in the shallow aquifer in the calcarenite (13–23 m) and from two deep wells in the deep sandy/gravelly aquifer (55–77 m) were collected in May and October 2024. Waters physicochemical parameters were measured: temperature 16.6–22°C, electrical conductivity 835–6760 $\mu\text{S}/\text{cm}$, pH 7.7–8.8. MPs were collected on 60 μm mesh nets by on site filtration of water (100 L), pumped from each well. In laboratory,

the MPs were filtered on fiberglass filters (1.6 μm) for counting and chemical analyses. MPs were found in all the wells. Concentrations varied from 0.7 to 2.8 particles/L in May 2024 and from 0.5 to 3.5 particles/L in October 2024. Fibres represented the most abundant shape (average 85% in May and 72% in October) followed by fragments (11 and 13 % respectively in May and October) and less than 5% (average) of films, pellet and foam. Chemical characterization of MPs is under study. Results provided the first assessment of MPs in Pianosa groundwaters a sensitive ecosystem protected by the park, where anthropogenic pressure is today very low compared to the past. Next, we will assess the impact of MPs to groundwater fauna, crucial for ensuring the protection and biodiversity conservation of these sensitive ecosystems.

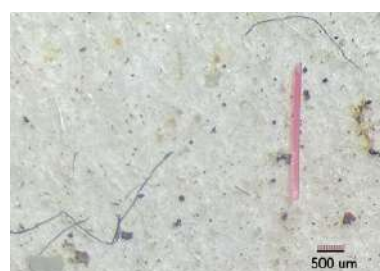


Fig.1 MPs identified in one of the waters well



Abundance and distribution of microplastics and microfibers in water and riverbank sediments of the Arno River (Tuscany) and the impact of the urban area of Florence

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Keywords: microplastic, natural-based textile microfibres, fluvial ecosystem, urban impact, risk assessment.

Associated conference sessions: 1, 2, 5,
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Fluvial ecosystems are among the main carriers of microparticles (MPC), comprising microplastics (MPs) and natural-based textile microfibers (MF_{TEX}), to the sea. Both MPs and MF_{TEX} were investigated for the first time in waters and riverbank sediments of the Arno River (Central Italy).

Seven sites from upstream to the river outlet were sampled in wet and dry seasons (April and July). In water, a specific sampling and analytical protocol allowed to distinguish MPC larger than 60 μm (MPC_{>60}) and MPC smaller than 60 μm (MPC_{<60}).

In the Arno waters, MPC contamination (up to 6×10^4 particles/L) was found at all sites. More than 99% of the total MPC were smaller than 60 μm . The MPC_{>60} fraction was formed mainly by fibers (76%), fragments (23%) and films (1%). Natural-based textile fibers represented 70% (average) of all the MPC_{>60} detected. Polyethylene terephthalate (PET) represented the most abundant polymer (38%) among eight classes identified. Calculate MPC fluxes (particles/day) are in the order of 10^{12} and 10^{13} in dry and wet seasons, respectively.

In riverbed sediments, MPs abundances ranged from 20 ± 6 to $2,960 \pm 941$ particles/kg d.w. and MF_{TEX} from 80 ± 25 to 380 ± 121 particles/kg d.w. Fragments (81%) and fibers (17%) were the most abundant shape, and fibers of the total in both seasons. Approximately 25% of the total MPC was formed by tire and road wear particles (TRWPs) made of styrene-butadiene rubber (SBR), followed by PE and PP (around 20%), while MF_{TEX} accounted to 21% of MPC.

The spatial distribution of MPs observed from upstream to the outlet showed a preferential downstream accumulation of MPs in river sediments, in

both seasons, with MPs polymers abundances higher in sediments at the outlet sites. TRWP were especially abundant at river sites sampled in the Florence city center (240 ± 76 particles/kg d.w) or next to the highway (120 ± 38 particles/kg d.w). The high presence in water and sediments of MF_{TEX} suggests a strong contribution from domestic and commercial sewage effluents, associated with laundering, while the abundance of SBR fragments is associated to vehicular traffic and areas with intense traffic flow, such the metropolitan area of Florence. MPs were found to pose risk in sediments, with sites from the urban area of Florence up to the river mouth falling in the medium to high-risk category (II to IV) and in the danger risk category (V) considering the polymer toxicity.

The metropolitan area of Florence was identified as a MPC hotspot, with many pollution sources due to the urbanization, intense traffic flow and the potential impact of over-tourism phenomenon affecting the city (e.g. laundry associated to short term accommodation or restaurants).

Results showed that MPC negatively affect the quality of the Arno River waters and riverbank sediments, representing a source of MPC to the Mediterranean Sea, with an estimated total mass of discharged MPC of about 29 tons/year (t/y) with MF_{TEX} accounting for 1 t/year.



Figure 1. SBR particles in the Arno River sediments



A Rapid Monitoring Protocol for Complex Microplastic Mixtures: Combining Portable NIR Spectroscopy with Machine Learning

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Keywords: Chemometrics, Near-infrared spectroscopy (MP), Microplastic, Quantification.

Associated conference sessions: 1

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The pervasive nature of microplastics (MPs) and their escalating ecological impact have intensified the global demand for rapid, reliable environmental monitoring. In response, portable Near-Infrared (NIR) spectroscopy has emerged as a transformative tool for on-site analysis, offering high-throughput data acquisition directly in the field. However, the effectiveness of these portable devices hinges on the application of robust multivariate analysis to accurately decode the complex spectral signatures (*Figure 1*) required for precise polymer classification and quantification.

This study addresses this challenge by developing a machine learning-based method for the quantification of polypropylene (PP), polyethylene (PE), polystyrene (PS), and polyethylene terephthalate (PET) in a mixture based on a sample's NIR spectrum.

To ensure that the models were trained using representative materials, microplastics were generated from everyday consumer objects. These materials underwent mechanical fragmentation to simulate the physical degradation found in nature, resulting in realistic, MP-sized particles. For data collection, particles were dispersed onto a metallic substrate. Spectra were then acquired at random positions across each sample using a compact NIR spectrometer (908-1676 nm). Afterwards, the resulting spectral library, comprising both pure polymers and complex binary to quaternary mixtures to reflect real-world pollution heterogeneity, was then curated and pre-processed.

The analytical workflow utilized Principal Component Analysis (PCA) to explore data structures,

followed by the calibration of four individual Partial Least Squares (PLS1) models. To ensure the highest level of reliability, these models were validated through a double cross-validation procedure and an external validation set composed of new polymeric mixtures from different starting materials. Furthermore, model stability was tested by introducing potential environmental interferents.

Finally, the validated models were used to predict the composition of real environmental samples from Sardinia, Italy, with results benchmarked against an independent analysis protocol. Performance parameters, specifically the R^2 and Root Mean Square Error (RMSE), demonstrate that portable NIR spectroscopy, coupled with advanced chemometric modelling, provides a powerful solution for the quantitative analysis of microplastics in complex, environmentally realistic scenarios.

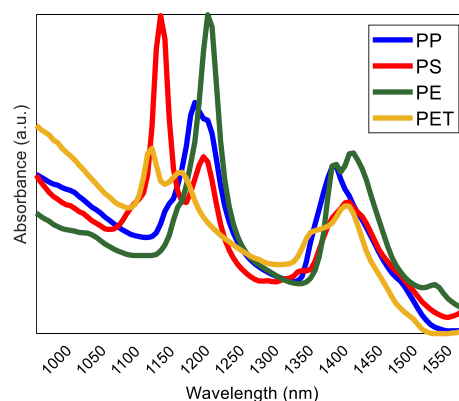
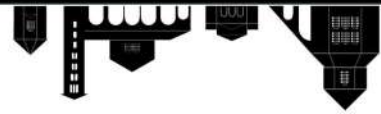


Figure 1. NIR spectra of pure PP, PS, PE and PET.



Identifying sources of microplastics in a city: a case study of an industrial catchment

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Keywords: sources, microplastics, gully pot, industrial catchment, city.

Associated conference sessions: 1, 5

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Cities are hubs for activities and objects that release microplastics (MPs) into the environment. This study focuses specially on sources carried by stormwater runoff, as this is one of the primary pathways for MP pollution into the natural environment. Identifying sources remains a key challenge for implementing effective source-reduction strategies to limit the spread of MPs into the natural environment. Studies have shown that the four main categories sources of MPs carried by stormwater runoff are: roads and traffic, building facades and rooftop, economic activities and plastic waste (Österlund et al., 2023). The relationship between urban land use and MP concentrations has been demonstrated (Iannuzzi et al., 2024), but no study has examined what occurs within a homogeneous urban catchment. It is therefore relevant to question whether MP concentrations are homogeneous across an urban catchment, and if not, how can we identify the sources responsible for these differences? This study examined MP concentrations in eight gully pot within an industrial catchment located in the Lyon metropolitan area (France). Sediment samples were collected four times in each gully pot, allowing for an assessment of MP variability both within individual gully pot and between them. The concentrations found in the gully pot range from 17,857 to 7,020,000 of MP per kg of sediments, which corresponds to mass concentrations between 0.027 to 15.85 g/kg. These initial results highlight significant variability among the gully pot, which may indicate differences in contribution from sources. Consequently, this study developed a two-step method for identifying sources. The first step was to draw up a list of potential sources near the gully pot, and determining the appropriate metrics to characterize them. The second step consisted of defining the areas of influence which are the sub-catchments. To achieve this objective, it was necessary to identify the watershed that drains gully pot. A buffer zone was then added around this area to

account for local atmospheric deposition that could readily enter the hydrological influence zone. Once these steps were completed, statistical models were tested to better understand the relationship between different sources present around the gully pot and the MP concentrations. Influencing factors were also used in this analysis, to consider the permeability between private spaces and public roads as a potential amplifier of microplastic particle transport to the gully pots. Figure 1 below summarizes the approach and method used in this study.

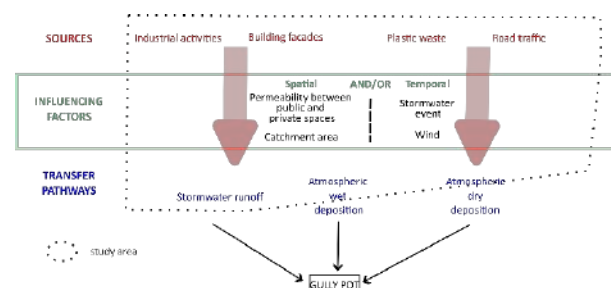
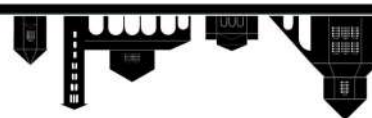


Figure 1. Conceptual diagram illustrating the identification of sources at the sub-catchment scale and the transport of MPs to gully pot.

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Polyethylene terephthalate weathering in cryoconite holes

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Keywords: plastic, biodegradation, cryoconite.

Associated conference sessions: 1

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Plastic contamination is widespread even in remote and cold ecosystems. Once in the environment, plastics can undergo various weathering processes, such as fragmentation and biodegradation. To date, most studies have focused on aquatic systems and soils, while comparatively little attention has been given to glacial ecosystems, despite evidence that contamination occurs there as well (Crosta et al., 2022).

This study presents the results of a microcosm experiment designed to investigate plastic weathering processes in cryoconite holes. Cryoconite holes (Fig. 1)—small ponds found on glacier surfaces, containing meltwater and sediment at the bottom—are

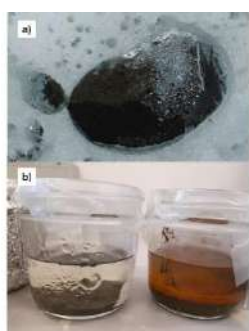


Figure 1 a) Example of a cryoconite hole.

b) Example of microcosms.

biodiversity hotspots, and may therefore be more likely to host microbial communities capable of degrading plastics. Experimental conditions included sterile and non-sterile cryoconite, as well as dark and light conditions. All microcosms were incubated in a phytotron at 4 °C and 12 h light:12 h dark photoperiod for six months. In one set of microcosms, a square-shaped polyethylene terephthalate

(PET) film was added. Bacterial communities were characterized in both cryoconite and on PET plastisphere, and Gel Permeation Chromatography (GPC), Fourier Transformed Infrared Spectroscopy (FT-IR) and Scanning Electron microscopy (SEM) analyses were performed to assess the integrity of the PET film.

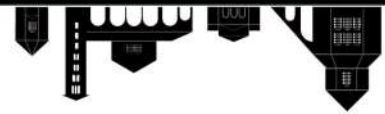
Results revealed marked degradation, particularly under biotic and dark conditions. The bacterial communities associated with the PET plastispheres differed significantly from those of cryoconite. Temporal shifts in community composition, together with a decrease in alpha diversity, suggest the selection of specific microbial populations. The genus *Clostridium sensu stricto* was more abundant on the plastisphere and under dark conditions, indicating a potential role in PET film biodegradation, consistent with literature data (Saleem et al., 2023). Functional analysis further identified a higher abundance of hydrocarbon-degrading genera on the PET plastisphere compared to cryoconite, which may reflect similarities in the metabolic pathways involved in their degradation (Wright et al., 2021).

In conclusion, this work demonstrates that plastic biodegradation can occur under simulated glacial conditions and that cryoconite holes host bacterial communities potentially capable of degrading plastics.

This work was funded by the Department for Regional Affairs and Autonomies of the Presidency of the Council of Ministers of Italy and supported by Bormioli Rocco.

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Model microplastics for studying fate and interactions in urban stormwater runoff

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Associated conference sessions: 1

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Urban areas represent major emission sources of microplastics (MPs), notably through their sewerage networks. In Lyon, the combined sewer system — collecting both wastewater and stormwater — constitutes a dual pathway for pollutant transfer toward receiving water bodies. In the context of climate change, intense rainfall events are expected to increasingly saturate these networks, leading to significant overflow discharges (Pyke et al., 2011). Storm overflows thus represent key — yet largely understudied — outlets for chronic MP emissions into the environment (Shafi et al., 2024).

Although a few studies have assessed MP composition and abundance in such waters, significant challenges remain, both in terms of sampling strategies and the heavy analytical workload required to extract plastics and quantifying it. Furthermore, the inherently dynamic nature of rainfall events generates substantial intra- and inter-event variability in MP loads and characteristics. Spatial heterogeneity and land use patterns add an additional layer of complexity to these fluctuations. Nevertheless, orders of magnitude and the predominance of certain polymer types can be established from existing data (Iannuzzi et al., 2024).

To better understand MP transfer dynamics within combined sewer systems and design effective remediation strategies, the use of doped model particles appears particularly promising (Mitrano et al., 2019). Doping with metallic tracers makes it possible to bypass the time-consuming pretreatment steps required for the quantification of MPs in complex media, and to improve analytical sensitivity through quantification by ICP-MS. The development of such model particles requires careful consideration of representativeness, transport-oriented study objectives, and filler homogeneity. To do so, polymer types were chosen in accordance with the abundances listed in the literature and a selection including density variability as it affects buoyancy. Subsequently, the

desire to study a diversity of shapes led to the selection of four distinct shapes design within specific protocols with an upper size limit of 500 μm , once again inspired by environmental samples (Table 1). Metal filler distribution was controlled at two scales by ICP-MS on milligram-range samples, while individual particle-scale was confirmed by X-ray tomography.

Table 1. MPs production and characteristics.

Polymer-metal (<i>shape</i>)	Measured density (g/cm^3)	Size (μm)
PE-Gd (<i>film</i>) (a)	0.941	80 – 350
PLA-Yb (<i>fiber</i>) (b)	1.259	100 ($\phi=33$)
PP-Y (<i>fragment</i>) (c)	0.917	100 – 250
PS-In (<i>microbead</i>) (d)	1.050	30 – 350

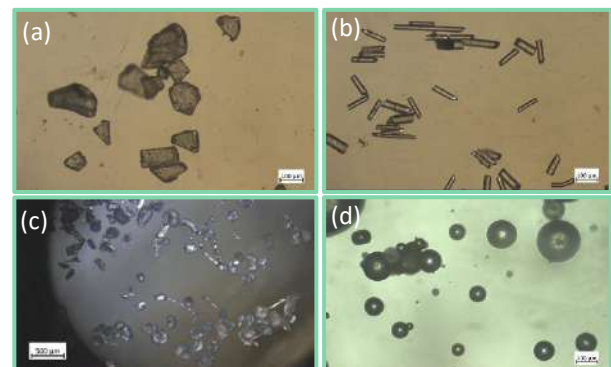
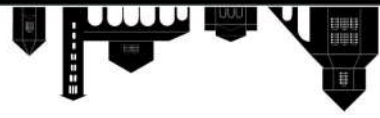


Figure 1. Microscopic observations of doped MPs

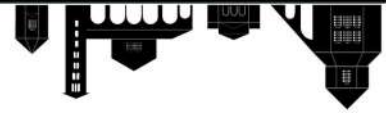
These models will serve as tools for understanding interactions with other organic and mineral compounds present in urban waters under lab tests. Settling velocity offers a macroscopic proxy for MP behaviour, while the use of doping extends this characterisation to complex environmental matrices, enabling robust assessment of MP transport dynamics in urban systems.

This work was supported by ANR TRANSPLAST and EUR H2O.



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Quantification and Characterization of Fibrous Microplastic Release from Synthetic Textiles: Preliminary Results of the SUMMIT Project

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Keywords: microplastic fibre, synthetic textile, washing cycle, ecodesign criteria.

Associated conference sessions: 1

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The release of fibrous microplastics (MPf) from synthetic textile materials represents an environmental issue of growing scientific concern. The European Commission highlights the matters of MPf release as a priority in the EU strategy for sustainable and circular textiles, estimating 40000 tons of synthetic fibres released annually from washing machine discharges.

This work represents a preliminary result of the SUMMIT project (Sustainable Mitigation of Microplastics In Textile), co-funded by the Piedmont Regional Program F.E.S.R. 2021/2027, which aims to define ecodesign criteria to reduce the release of fibrous microplastics from textile products throughout their entire life cycle.

The novelty of this work is the quantification and qualification of fibrous microplastic release from textile samples during simulated washing according to ISO standard 4484 1-2 (2023), the first available for determination of microplastics from textile sources. Two commercial reference garments (T-shirt and sweatshirt), widespread in the market and therefore frequently used and washed, were tested. A few issues were identified during the experimental approach particularly those associated with sample treatment, cross-contamination, filtration, and analysis using optical microscopy and FTIR micro-spectroscopy. At the same time, the main sources of variability and potential contamination were identified. Based on the findings, optimized protocols were proposed to enhance the

reliability, reproducibility, and standardization of analytical procedures. Moreover, these results were used to determine some criteria and operative conditions to be investigated in the future project's steps for microplastic release mitigation.



Figure 1. Methodology

This work was supported by Regione Piemonte through the regional program Switch (F.E.S.R. 2021–2027).

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Controlled Generation of Representative PET Micro- and Nanoplastics by Ethylene Glycol Fragmentation for Environmental and Toxicological Studies

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Keywords: Polyethylene terephthalate (PET), Micro and nanoplastics (MNPs), Glycolysis, BHET oligomer, Toxicology.

Associated conference sessions: 1

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Polyethylene terephthalate (PET) micro nanoplastics (MNPs) are widely distributed environmental pollutants. The studies on their biological effects remain limited by the lack of representative and reproducible reference materials. Here, we report a scalable ethylene glycol fragmentation (EGF) approach for the controlled production of PET MNPs from commercial pellets, bottle-grade, and film-grade PET, addressing the current lack of standardized materials. The process generated two distinct fractions. Fraction Ea consisted of BHET-based oligomeric nanoplastics with hydrodynamic diameters of ~275–374 nm and low polydispersity (PDI 0.26–0.35), while fraction Eb comprised larger BHET-based aggregates (~1.3–1.9 μm) with broader size distributions. Zeta potential measurements showed values of –34 to –36 mV for Ea, indicating good colloidal stability, compared to less negative values (–27 to –33 mV) for Eb.

Structural and chemical characterization by TEM, ATR-FTIR, and AFM confirmed that Ea particles are semi-crystalline oligomeric fragments, whereas Eb corresponds to non-covalent aggregates of BHET monomers. The EGF approach yielded 27–33% Ea and 67–73% Eb fractions, which is significantly higher than the ~5% yield reported for PET nanoplastics prepared by using TFA-based acid hydrolysis (Rodríguez-Hernandez et al., 2019). The EGF method also exhibited better control over particle size without using the traditional surfactants.

In THP-1-derived macrophages, both fractions induced a dose-dependent decrease in cell viability, with significant effects observed at ≥ 0.5 mg/mL. At higher concentrations (1-5 mg/mL), PET MNPs triggered LDH release and increased IL-1 β production,

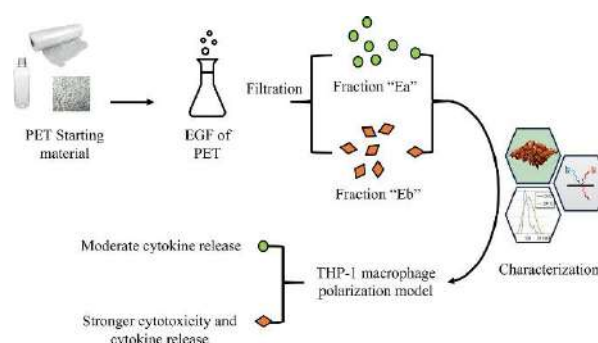


Figure 1. Schematic of PET micro- and nanoplastics generation via EGF, yielding Ea (nanoplastics) and Eb (microplastic aggregates), followed by characterization and macrophage response.

indicating proinflammatory and immunotoxic responses associated with M1 macrophage polarization. Overall, this work establishes a reproducible route to generate source-specific PET MNPs with defined physicochemical properties, enabling more reliable and comparable environmental and toxicological studies.

Acknowledgements

This work was supported by ISIS@MACH ITALIA Research Infrastructure and the ISIS Neutron and Muon Source (UK).

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Fabrication of PET nanoplastics and their interactions with chlorpyrifos and bisphenol A

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Associated conference sessions: 1, 2

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Polyethylene terephthalate (PET) is one of the most used plastics worldwide and although it is technically recyclable, it remains among the most abundant polymers found in the ocean in the form of macro but also micro- and nano-plastics. Recent studies have shown that PET particles, due to their physicochemical properties such as particle size, crystallinity, surface functional groups, high specific surface area, and hydrophobicity, can interact with and adsorb organic contaminants from the surrounding environment, acting as vectors for co-transport and bioavailability enhancement of pollutants (Magri, 2021; Costa, 2024; Dharshan, 2025).

Understanding the interactions between PET nano-plastics and environmentally relevant organic pollutants is therefore crucial, particularly in the context of combined ecotoxicological effects on aquatic organisms. However, research in this field is still limited, mainly due to challenges associated with the reproducible fabrication of nano-plastics and the assessment of their adsorption behavior.

In this work, PET nano-plastics were fabricated using a top-down vibromilling approach and systematically characterized. Dynamic Light Scattering, zeta potential, Nanoparticle Tracking Analysis and UV-Vis spectroscopy were employed as quantitative tools, while FT-IR and raman spectroscopy were used to investigate their chemical properties. The results demonstrate that an optimized fabrication protocol enables efficient fabrication of PET nano-plastics of a representative morphological variability while minimizing thermal and chemical degradation.

These findings provide a solid base for investigating the interaction and adsorption mechanisms of chlorpyrifos and bisphenol A onto PET nano-plastics. Detailed chemical analyses clearly demonstrate the interactions between these pollutants with the nano-plastics, leading to the formation of stable complexes that may influence the environmental fate of the individual components. The developed PET-pollutant complexes will subsequently be used in

toxicological exposure experiments on marine organisms to better elucidate their role as pollutant vectors and assess their potential ecotoxicological impact.

This work was supported by Istituto Italiano di Tecnologia and the University of Milano-Bicocca

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Towards validated and standardised workflows for microplastic quantification

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Keywords: microplastics, harmonisation, method validation, reference materials, data comparability

Associated conference sessions: 1, 2, 3, 4, 5, 6

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Microplastic (MP) analysis relies on complex, multi-step analytical workflows in which methodological choices made at early stages directly affect quantitative results, including both particle number- and mass-based approaches. Evidence from the literature indicates that the predominant source of variability stems from insufficient method validation and harmonisation of analytical procedures [1–3].

Measurement of MP polymer type, number- and mass-based quantification, and subsequent data processing represent the final outcome of a sequence of interdependent steps, including sampling, sample pre-treatment, extraction, and filtration. Variations in any of these steps—such as digestion efficiency, filter retention behaviour, contamination control, and spectral and thermal parameter selection—systematically lead to non-comparable datasets across laboratories and analytical techniques. Without explicit control of these factors, MP data frequently lack cross-study consistency, limiting their interpretation in exposure assessment studies and their applicability in regulatory contexts requiring harmonised, validated and traceable measurements. Evidence from interlaboratory and cross-technique studies, encompassing both number-based (IR and Raman spectroscopy) and mass-based thermo-analytical (TED-GC/MS and Py-GC/MS) approaches, demonstrates that differences in sample preparation, filtration and analytical parameter selection can outweigh instrumental performance in determining MP results.

This work presents a workflow-oriented framework for MP analysis that identifies critical control points and defines the methodological elements required to control them. For each key analytical step, the role of Standard Operating Procedures in defining operational boundaries is addressed, together with the use of fit-for-purpose reference materials to assess recovery and

performance across the analytical workflow. The implementation of systematic quality assurance and quality control measures, the establishment of reporting limits, and the role of interlaboratory comparison studies are discussed as essential components for ensuring reproducible, traceable and standardised MP measurements, providing a practical basis for improving cross-laboratory and cross-technique comparability in regulatory-relevant applications.

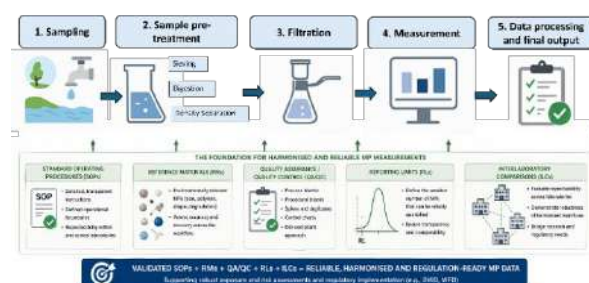


Figure 1. Overview of control points for harmonised MP analysis

The authors thank the project 21GRD07 PlasticTrace which has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States. This work was supported by Bundesanstalt für Materialforschung und -prüfung (BAM).

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Reference materials for precise and accurate microplastic results

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Keywords: microplastics, reference material, plastic fibers, quality by design

Associated conference sessions: 1

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Accurate analysis of microplastics is based on validated methods and the use of standardised protocols. Therefore, reference materials are essential to determine recovery rates and optimise the existing workflows.

Reference materials are well characterised, as well as homogenous and stable in at least one property of interest (Emteborg, 2024). They are intended for a defined use and should mimic the reality in terms of selected particle properties and concentrations. Especially for micro- and nanoplastics, aged surfaces and irregular shapes should be covered.

The Quality-by-Design approach helps to select the users need and defines a target product profile with mandatory and desired particle properties (Altmann, 2025). After defining the target specifications, the particle production must be controlled and the particles need to be well characterised. An optimisation process helps to guarantee a consistently high-quality product that complies with the chosen specifications, even over repeated batches. Finally, the materials should be tested for their performance in the intended application and validated for homogeneity and stability. A scheme of the workflow is presented in Figure 1.



Figure 1. Overview of steps needed for reference material production for test material development and environmental exposure studies

We will address different top-down production processes with their limits and challenges, especially when varying polymer type, shape and size ranges. The required **concentration** may also need to vary between mg and µg depending on the intended use. For example, when considering the Urban Wastewater Treatment Directive and the monitoring of

microplastics in the influent and effluent of the wastewater stream as well as sludge, different needs for various plastics and concentrations are required. The effluent will have less microplastics compared to the influent, while the sludge will likely vary in the polymer types present. Thus, polymer types for particle production should focus on thermoplastics such as polyethylene, polypropylene, polystyrene and polyethylene terephthalate, which are relevant in these scenarios.

In addition to irregular spherical particles, we have also developed a fiber reference material candidate (Figure 2). These candidate reference materials consist of polyamide or polyester textile fibers.

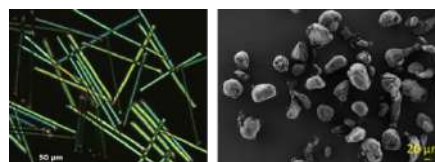
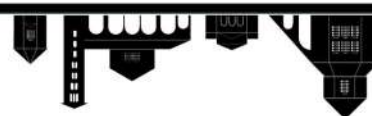


Figure 2. Microscopic images of microplastic fibers and particles

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Microfibers in drinking water, a new analytical challenge: detection of disinfection by-products of microfibers

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Keywords: Microfibers, DBPs, Disinfection by-products, Drinking water.

Associated conference sessions: 1, 2, 3.

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Microfibers (MFs), primarily released during textile laundering, constitute a major component of microplastic pollution in aquatic ecosystems (Haque et al., 2024). Due to their persistence and inefficient removal in conventional water treatment plants, MFs can contaminate various water sources, including groundwater (Re, 2019).

Recent research indicates that MFs may serve as precursors for the formation of disinfection by-products (DBPs) during chemical treatment processes (Allen et al., 2022). Given that DBP exposure is associated with significant adverse health effects (Das et al., 2025), investigating the role of microplastics in DBP production is essential for enhancing water safety.

This study evaluates the formation of 66 DBP species resulting from the chlorination and chloramination of different MF types. The experimental setup involved nine MF varieties, including natural cotton, Lycra, Nylon, and textured polyester (PLTSO), analyzed in both pristine and aged states. MF samples (15 mg/L) were subjected to chlorination using sodium hypochlorite (NaClO) for 24 hours and chloramination using monochloramine (NH₂Cl) for 72 hours, both at 25°C. Targeted analysis was performed using GC-MS/MS in multiple reaction monitoring (MRM) mode to ensure high selectivity and precise quantification. Procedural blanks were analyzed alongside experimental samples to verify that the formed DBPs originated from the MF-disinfectant interaction.

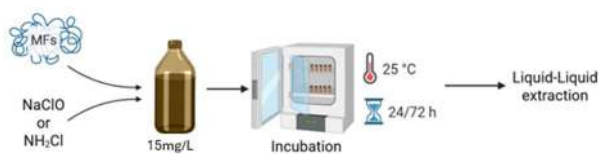


Figure 1. samples treatment setup

Results revealed that DBP concentrations in chlorinated samples were significantly higher than in procedural

blanks, with aged cotton and fresh Cotton exhibiting the highest yields. Under chlorination (NaClO), the predominant DBP class was haloacetic acids (HAAs, 46.0%).

Conversely, total DBP levels under chloramination (NH₂Cl) did not significantly deviate from blanks for the overall groups, although fresh cotton and Lycra samples showed notable absolute concentrations. Under chloramination, the primary class was haloketones (HKs, 50.3%). These findings underscore the potential contribution of MFs to DBP formation in drinking water and emphasize the need for further research into specific mechanisms and mitigation strategies.

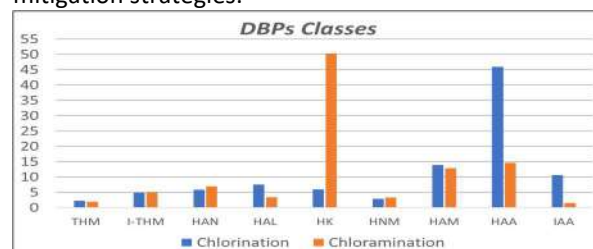


Figure 2. DBPs comparison from different treatment

This research was supported by University of South Carolina's Clean Water Institute and MUSA project (Multilayered Urban Sustainability Action), funded by the Italian Ministry of University and Research (MIUR/MUR) within the framework of the National Recovery and Resilience Plan (PNRR) and implemented through the University of Milano-Bicocca.

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A Dye-Based Approach for Quick Synthetic Microfibres Characterisation in Water Samples

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Keywords: microplastics, microfibres, water microplastics contamination, textile dyes, characterization techniques.

Associated conference sessions: 1

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Microfibres (MFs), a dominant fraction of microplastics (MPs), are pervasive environmental contaminants originating mainly from synthetic textiles (Sivasankar and Sunitha 2024), contributing up to 34.8% of oceanic MPs (Boucher and Friot 2017). However, current analytical approaches as FTIR and Raman spectroscopy, are time-intensive and not specifically validated for MFs (Ivleva 2021; Mariano et al. 2021). This study introduces a rapid, low-cost two-step colorimetric method for MF identification and quantification using commercial textile dyes. The first step enhances fibre visibility for Raman analysis, achieving polymer recognition rates up to 100% for PET, 86.7% for PP, and 73.3% for PE, while polyamide showed limited detectability (~6.7%). The second step, combining higher dye concentration and filters solvent cleaning, enabled direct visualization and image-based quantification, with dyeing efficiencies reaching 94.4% for PE and ~72–75% for other polymers. The method also allowed dimensional characterization (length up to ~10 mm; diameter down to ~0.013 mm). Overall, this approach significantly reduces analysis time while maintaining robust identification, representing a promising tool for MF monitoring in environmental samples.

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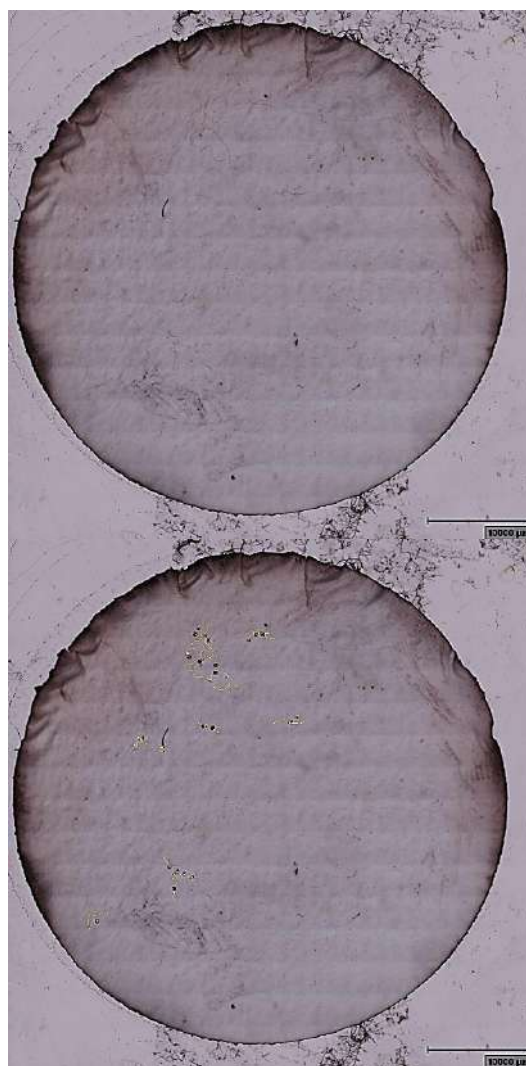


Figure 1. PE fibres highlighted with synthetic textile dye (top) and individuated with ImageJ software (bottom)



Assessment of hydrothermal carbonization (HTC) efficiency for microplastic removal from sewage sludge

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Keywords: sewage sludge, microplastics, hydrothermal carbonisation, degradation

Associated conference sessions: 1

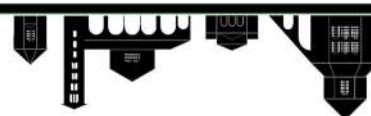
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Sewage sludge from civil and industrial wastewater treatment is a relevant vector for the transfer of microplastics, pathogens, and other contaminants to agricultural soils, where it is commonly applied as fertiliser due to its high organic and nutrient content. The development of effective technologies for the abatement of such pollutants is therefore essential before soil application (*Hassan et al., 2023*). Among these, hydrothermal carbonisation (HTC) is a promising approach, as it modifies sludge chemico-physical properties and may mitigate the persistence of contaminants within the matrix (*Prus et al., 2025*). The present study focuses on the effectiveness of HTC in reducing microplastic content in sewage sludge under different thermal conditions (temperature and time). The effects of the thermal treatment were evaluated using two analytical techniques commonly used for microplastic analysis: Nile red staining combined with fluorescence microscopy and analytical pyrolysis (Py-GC/MS). The two approaches were lastly compared, highlighting the main advantages and limitations. The aerobic and anaerobic sludges considered had a microplastic content ranging from 2 to 9 mg/g, consistent with values reported by *Vollertsen and Hansen (2017)*. Polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET) were identified as the main polymers, with particle sizes ranging from 1 to 1000 μm . Post-HTC analyses revealed a significant decrease in both microplastic mass and particle number, reaching up to 94% reduction in the anaerobic sludge at 250 °C and confirming temperature as the most relevant operating parameter.

The degradation behaviour depended on polymer chemistry: PET is the most susceptible to degradation, while PE has a greater resistance under hydrothermal conditions, in agreement with trends reported by *Xu & Bai (2022)*. Comparison between the two analytical approaches highlighted that fluorescence microscopy is suitable for preliminary and quantitative screening, whereas Py-GC/MS remains essential for the chemical characterisation and polymer identification. Both techniques produced quantitative results of the same order of magnitude.

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From wash to wear: a cross-value chain assessment of textile and washing process variables for sustainable, system-level design guidelines

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Keywords: microfibers, fibre release, washing machine, textiles, design-driven approach

Associated conference sessions: 1, 4

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Microplastic fibres originated from textiles are one of the major sources of microplastics in the environment.

The scientific literature indicates that several variables may influence microfibre release from domestic washing machines: water temperature and spinning speed are generally associated with increased fibre shedding, while higher garment loads appear to reduce microfibre release (Sheikhi *et al*, 2024). In addition, the role of textile characteristics (such as fibre origin, yarn construction fabric structure, and surface finishing) appears to be crucial in fibre detachment mechanisms (Gliadelyté *et al*, 2025).

Recent studies highlight that most of the published work on the topic fail to produce reliable evidence about fibre release mechanisms, due to methodological limitations and insufficient statistical rigour (Tedesco *et al*, 2024). To address this gap, an experimental workflow was implemented, consisting of a scalable test procedure for assessing microfibre release during washing using a real scale commercial washing machine.

A Design of Experiment was developed to enable the evaluation of microfibre release as a function of washing parameters and textile properties, ensuring the isolation of each variable. At a screening level, five washing parameters were selected (load weight, detergent, spinning speed, temperature and load composition). The experimental setup included sampling the drained water (x3) and performing a vacuum filtration using a 10 µm filter mesh and a gravimetric assessment. The procedure is based on a protocol from UNI EN ISO 4484-1:2023 and UNI EN ISO 4484-3:2023, specifically adapted to enhance ease of replication through the sub-sampling of wastewater.

Some preliminary washing cycles were run to stabilise the release and check the consistency of the testing procedure. The tests were conducted by washing cotton and polyester t-shirts using cotton cycles at 30°C and 800 rpm and performing two blank

cycles (without load) between one test and another.

After two consecutive cycles without load, fibre release fell below 10 mg, indicating minimal carryover contamination between subsequent washing cycles. One example of the results from the activity concerns the relationship observed between washing load and fibre release, with larger loads yielding lower fibre emissions, as in Figure 1.

By enabling a shared understanding of cause-effect relationships of microfibre release, this work aims to support evidence-based innovation across value chains, from household appliance design to textile design and manufacturing, contributing to sustainable solutions for reducing microfibre release.

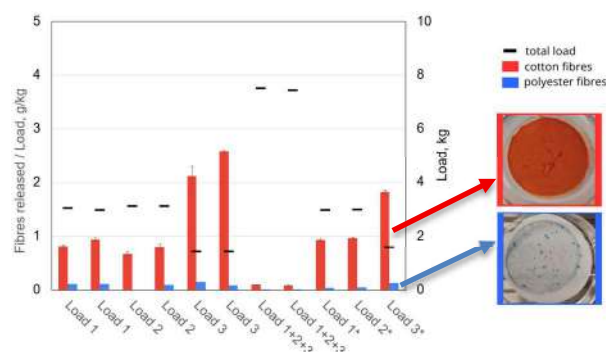
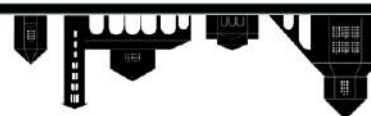


Figure 1. Microfibres released per kg of laundry load (red - cotton; blue - polyester) and load size (black)

This work is supported by the Interreg IPA-ADRION Programme through the project “MISSION4WATER”.

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Analysis and characterisation of microplastics in composts

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Keywords: microplastics, compost, organic waste.

Associated conference sessions: 1

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This study aims to investigate the relationship between the management of organic waste and the emerging issue of microplastic release into the environment. Organic waste is still affected by the presence of plastic contaminants, primarily due to improper waste disposal practices. Moreover, even compostable bioplastics may present criticalities during degradation processes. As a result, microplastics can be detected in the final products of biological treatment processes of the organic fraction (compost and digestate).

Analyses of microplastics in these matrices are still less widespread than in other sectors, and current regulatory constraints regarding impurities generally consider residues larger than 2 mm (e.g. EN 13432 standard).

In this study, five compost samples are analysed. These samples originate from the treatment of the organic fraction of municipal solid waste (including food and garden waste) in five different facilities characterised by distinct treatment processes (e.g. aerobic composting, wet continuous anaerobic digestion followed by aerobic post-composting, dry batch anaerobic digestion followed by post-composting).

The analytical procedure is structured in sequential steps. First, larger plastic impurities (> 2 mm) are isolated and quantified. Then, microplastics < 2 mm are extracted through chemical digestion and density separation processes, which are commonly applied to samples with a high organic content (Naeem *et al.*, 2024).

After extraction, microplastics < 2 mm are quantified and classified based on their number, size, colour, and morphology (by using stereomicroscopy with image capture and processing). Specifically, based on the images obtained, the total microplastics count, as well as their morphological and colour classification, is carried out manually for each size fraction (2000-500 μm , 500-212 μm , 212-25 μm). Microplastics are categorised into five groups based on morphology:

fibres, fragments, films, foams, and pellets. In terms of colour, they are divided into six groups: transparent /white, black, red, blue, green, and brown.

The results indicate that the content of larger impurities (> 2 mm) varies significantly among the analysed samples, ranging from 0.12% to 0.25% on a dry weight basis. Furthermore, the number of microplastics < 2 mm is characterised by a high variability (Table 1).

Table 1. Microplastics < 2 mm count in the five compost samples (minimum and maximum number of pieces).

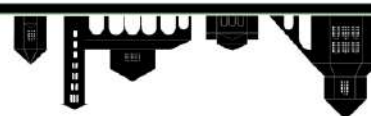
SIZE (μm)	Number of fragments	
	Min	Max
2 mm-500 μm	31	164
500-212 μm	97	388
212-25 μm	132	590

With regard to colour distribution, transparent particles represent the dominant fraction (49%-73%), generally followed by green particles (< 32%). In the sample subjected exclusively to aerobic composting, coloured fragments account for more than 50% of the total. In terms of morphology, films constitute by far the predominant category, accounting for 61%-73% of the detected microplastics.

Further investigations will include polymer identification. In addition, the results will be correlated with treatment plant characteristics and the quality of the processed organic waste, to propose optimisation strategies aimed at reducing microplastics in the outputs of biological treatment processes.

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Microplastics in inflowing streams of Lake Orta (Northern Italy)

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Keywords: microplastics, streams, μ FT-IR, freshwater.

Associated conference sessions: 1

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Freshwater systems are increasingly recognised as critical compartments in the environmental fate and transport of microplastics, yet small tributaries remain largely overlooked despite their potential role as direct sources to larger water bodies. In this context, the present study investigates the occurrence, composition, and characteristics of microplastics in six tributaries inflowing into Lake Orta (Northern Italy): Fiumetta, Pescone, Qualba, Plesina, Lagna, and Pellino (Fig.1). Sampling was carried out in November 2025 at the mouth of each stream using 100 μ m plankton nets coupled with a flowmeter to quantify filtered volumes. Suspected particles were isolated and subsequently characterised by micro-Fourier Transform Infrared spectroscopy (μ FT-IR), allowing polymer identification and morphological classification (shape, size, and colour). Out of 91 analysed particles, 31 were confirmed as plastics, with microplastics (<1 mm) accounting for the vast majority (94%). Fragments represented the dominant particle type (48%) and were primarily composed of polypropylene. Polymer analysis revealed a clear dominance of polypropylene (58%) and polyethylene (26%). Microplastic concentrations varied among tributaries, ranging from 0.04 plastics m^{-3} in the Pescone stream to 0.68 plastics m^{-3} in the Lagna tributary. This spatial variability, together with differences in particle typology, suggests the influence of local sources and catchment-specific pressures, including urbanisation and industrial activities. Overall, these findings highlight the role of small tributaries as non-negligible contributors of microplastics to lacustrine systems and underline the need to better integrate these environments into monitoring frameworks. Ongoing work is addressing seasonal variability to further elucidate transport dynamics and source patterns.



Figure 1. Map of Lake Orta (Northern Italy) showing the sampled tributaries and their inflow points.

Acknowledgments: This study was financed by Cariplo Foundation.



Integrated analysis of microplastics in marine sediments and air involving GC-MS-pyrolysis and Agilent LDIR spectroscopy with a single shared sample preparation workflow.

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The widespread use of synthetic polymers has caused a global environmental crisis, with microplastics found in various environments and posing risks to human health and ecosystems. Microplastics (MPs) are emerging contaminants whose characterization requires advanced analytical approaches. For a complete assessment, it is necessary to integrate morphological characterization and mass quantification. The most critical step is sample preparation, which is essential to eliminate interferences while maintaining the integrity of the particles. The Agilent LDIR 8700 (Laser Direct Infrared) allows automatic morphological analysis with polymer identification in a short time, while the Frontier Lab pyrolyzer, coupled with Agilent GC/MS, offers accurate quantification of polymer mass. The integration of these techniques allows the use of a single preparative phase, optimizing time, efficiency, and reproducibility. This study demonstrates the effectiveness of the method on air samples collected by passive filtration and marine sediments from coastal and offshore areas.

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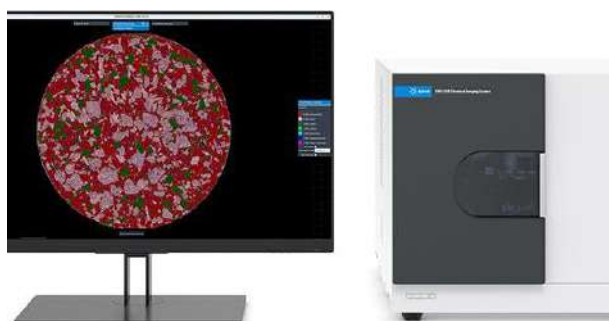


Figure 1. Chemical image obtained with the Agilent 8700 LDIR showing the spatial distribution and automated identification of microplastic particles on a filter through high-resolution spectroscopic analysis.



Detecting the route of Mediterranean Litter, tracing back natural volcanic pumice

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Keywords: Pumice, Plastic, Cyclone Harry, Mediterranean Sea, Pollution.

Associated conference session: 1

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Major storms in the Mediterranean Sea play a key role in redistributing floating debris along coastal and marine environments. The relationship between the action of large waves, strong winds, litter fate and redistribution is not well known.

This study focuses on the understanding of beach macro litter (≥ 2.5 cm) dynamics in the Ionian Sea. The novelty of this project is the use of a natural geological analogue of floating plastic, to investigate the dispersion pattern and source area of pollutants. Floating pumice, with a specific chemistry, represents the best proxy to trace the effect of a major storm event like the Cyclone Harry, 16-23 January 2026, along the southern Italian coasts of Sicily, Calabria, Basilicata and Puglia.

Pumice is a highly vesicular volcanic rock characterized by low density and high buoyancy, allowing it to float and can be transported over long distances by sea currents and is commonly found in this area. The study of its chemical composition and provenance are in progress.

A total of 28 beaches and 1 point bar deposit in the Neto River were surveyed, combining systematic sampling of surficial sediments and plastics and documenting with photographs post storm depositional features. Field observations revealed the presence of a variety of light floating anthropogenic litter (plastic debris, nets, toys, lighters, beach umbrella tip, straws, PET and PE bottles, polystyrene, writing pens, expanded clay balls, aluminum cans, tanks, metal caps, light bulbs, shoes and ropes) mixed with natural materials (vegetal remains, fresh and burnt wood, seaweed balls and white pumice).

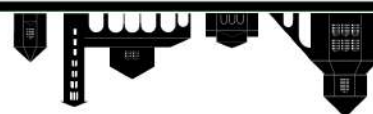
Marine pollution by anthropogenic litter and floating macro-debris observed during this campaign, are generated by human activities, and redistributed due to natural drivers as wind and surface circulation. This pollution poses a major concern due to its impact on the health of residents and on tourism in these regions.



Figure 1. Post storm depositional features in Lido Marini (LE) after Cyclone Harry. The upper panel shows the accumulation zone formed by big waves; lower panel provides a close up showing a mixture of natural and anthropogenic materials.

Pumice is circled in red.

This work is promoted by the Department of Excellence TECLA position on “Monitoring of the effects of ongoing climate warming and mitigation strategies and techniques”. The study is prepared thanks to the facilities of The Laboratory of Provenance Studies at DISAT.



Microplastics release from UHMWPE ski bases: tribometer simulation and spectroscopic analysis

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Keywords: ski bases, snow tribometer, UHMWPE, FTIR spectroscopy, Raman spectroscopy
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Microplastics represent an emerging source of pollution in natural ecosystems worldwide, including alpine environments where snow and ice act as receptors for these contaminants.

Since winter sports, in particular alpine skiing and ski mountaineering, are increasing in popularity, the potential release of microplastics from sporting equipment, such as ski bases, is increasing, posing an additional threat to fragile mountain ecosystems. This research focuses on the release of ultra-high molecular weight polyethylene (UHMWPE) microplastics during alpine sports activities.

The volume of material removed due to the interaction between the snow surface and the polymer surface is analysed in two different contexts: (i) from samples collected along ski slopes in the Valle d'Aosta region, and (ii) from laboratory simulations using a snow tribometer (Figure 1), which reproduces the sliding phenomenon under controlled snow temperature and speed conditions.

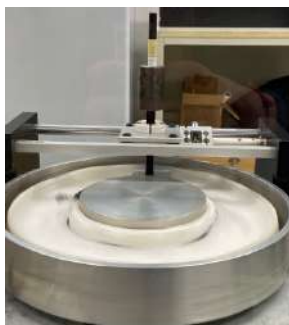


Figure 1 the snow tribometer with UHMWPE sample sliding on a track made of natural snow

Samples from both contexts undergo the same extraction procedure before being analysed by means

of vibrational spectroscopy techniques. The first analysis is carried out using micro-FTIR spectroscopy to identify polyethylene particles. Subsequently, only the identified polyethylene particles are subjected to Raman spectroscopy analysis to detect the presence of carbon-based additives, which are peculiar of the UHMWPE used for ski bases (Figure 2).

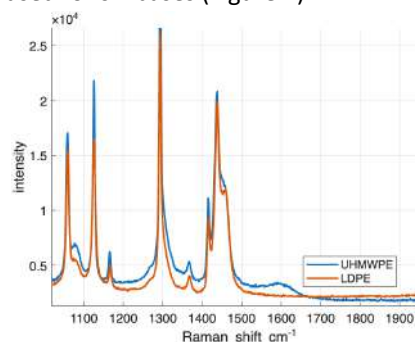
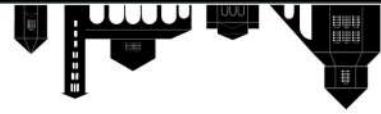


Figure 2 Raman spectra of the bulk measurements on UHMWPE and PE.

The applicability of the method is confirmed for both contexts, successfully isolating UHMWPE particles. The results of this study highlight the need to assess the environmental impact of microparticles released from ski bases and emphasize the importance of developing sustainable alternatives to commonly used UHMWPE bases.

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Microplastics at the Air–Sea Interface: Comparative Observations from the Maldives and the North Atlantic

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Keywords: Airborne microplastics; marine microplastics; air–sea exchange; black carbon; marine aerosol; North Atlantic Ocean; Northern Indian Ocean

Associated conference sessions: 1

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Microplastics (MPs) are now recognised as contaminants of both the ocean and the atmosphere, yet the processes controlling their exchange across the air–sea interface remain insufficiently constrained. This study presents a comparative perspective on airborne and marine MPs from two contrasting marine environments: the tropical northern Indian Ocean, based on measurements at the Maldives Climate Observatory Hanimaadhoo (MCOH), and the North Atlantic Ocean, based on recent preliminary observations collected on board R/V Oceania.

At MCOH, airborne MPs were collected using a deposition-box system, while marine MPs were sampled from adjacent coastal waters. Particle morphology, size distribution and polymer composition were investigated using optical microscopy and μ -Raman spectroscopy, and interpreted together with aerosol optical properties and black carbon measurements. Airborne MPs concentrations ranged from 0 to 10.3 MP m⁻³, with a mean of 3.1 ± 2.8 MP m⁻³, and were dominated by fibres. Marine MPs concentrations ranged from 0.12 to 2.69 MP dm⁻³, equivalent to 120–2690 MP m⁻³, with a mean of 880 ± 810 MP m⁻³. The physical and chemical properties of airborne and marine particles differed substantially, suggesting weak coupling between the atmospheric and marine reservoirs during the dry-season observation period. Low wind speeds likely suppressed wave breaking, bubble bursting and sea-spray-mediated transfer of MPs from the ocean to the atmosphere. Instead, airborne MP variability was more closely associated with polluted air-mass advection, enhanced black carbon and increased aerosol

scattering, indicating an important role of anthropogenic atmospheric transport.

Preliminary North Atlantic observations from R/V Oceania provide a contrasting open-ocean perspective, where stronger wind forcing, different source regions and more dynamic air–sea exchange conditions may influence the occurrence and properties of MPs. Together, these datasets highlight that MP transport between the ocean and atmosphere is not universal, but depends strongly on meteorological conditions, regional pollution sources, particle properties and local marine activity. The results demonstrate the value of combining MP analysis with aerosol-science tools to better understand the environmental pathways of plastic particles in marine systems.

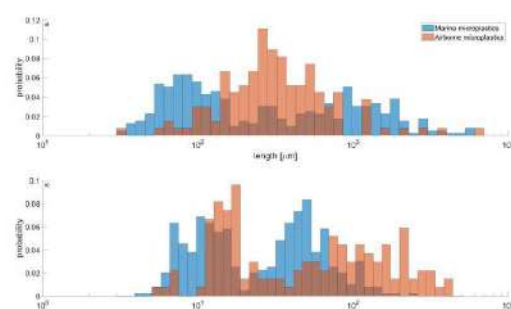


Figure 1 Probability distributions of particle dimensions for airborne and waterborne MPs. Histograms compare airborne microplastics (orange) and waterborne microplastics (blue) measured during the campaign.

This work was financially supported by the National Science Centre, Poland (Grant 2023/49/B/ST10/00513).



Hidden pollutants in food: Evidence of small microplastic particles (100–5 μm) in refined sugar from the Italian market

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Keywords: Microplastics, Sugar, Fourier-transform infrared spectroscopy, Raman spectroscopy, Polyvinyl chloride.

Associated conference sessions: 1

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Microplastics (MPs) are emerging contaminants increasingly reported in environmental and food matrices, raising growing concerns regarding potential human exposure. Among widely consumed food products, refined sugar represents an interesting yet underexplored matrix for assessing microplastic contamination. In this study, we present a novel analytical workflow enabling the detection and characterization of MPs down to 5 μm in commercial sugars without the use of chemical digestion. The approach relies on the simple dissolution of sugar in ultrapure water, thereby preserving particle integrity and minimizing analytical artefacts.

White sugar samples from major Italian brands and distributors were analysed using a complementary spectroscopic strategy: μ -FTIR imaging for particles ≥ 50 μm and μ -Raman spectroscopy for particles between 5 and 50 μm . The μ -Raman results are semi-quantitative and based on systematic sub-sampling of 34% of the filter area. Polymer-specific reporting limits were established using procedural blanks, allowing a robust distinction between true sample-derived MPs and analytical background contamination.

While μ -FTIR detected only limited numbers of MPs ≥ 50 μm , often below their respective reporting limits, μ -Raman analysis revealed a substantially higher abundance of smaller particles, exceeding 1000 MPs per 5 g sugar sample (Fig.1). The particle size distribution was strongly dominated by the 5–10 μm fraction, which accounted for the majority of detected MPs. Polyvinyl chloride (PVC) emerged as the most abundant polymer across all products, followed by polyethylene (PE), polystyrene (PS), polypropylene (PP) and polyethylene terephthalate (PET).

Beyond reporting contamination levels, this study highlights the analytical importance of resolving MPs in the < 20 μm size range, which accounted for approximately 90% of all detected particles but is not yet fully addressed by current regulatory frameworks.

In particular, the findings underline the need for harmonized and standardized methodologies for monitoring MPs in food matrices and suggest that current regulatory approaches - such as Commission Delegated Decision (EU) 2024/1441 on drinking water, which addresses MPs only down to 20 μm - may underestimate the most abundant fraction of MPs. Overall, this work demonstrates the value of high-resolution spectroscopic techniques for investigating microplastic contamination in refined sugar and provides a methodological basis for future exposure assessments and regulatory development.

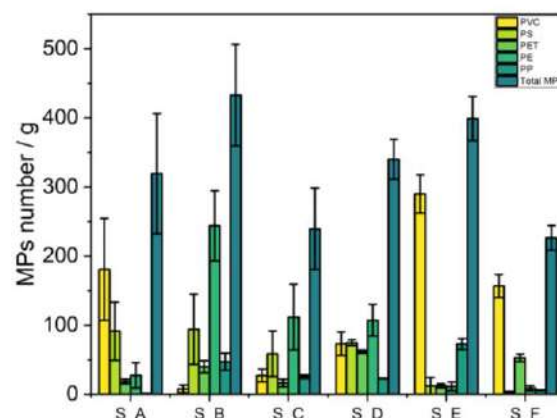


Figure 1. μ -Raman analysis: (A) Number of MPs in one gram of each analyzed sugar, divided for polymer type and the corresponding total amount.

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Session 2 – “Ecotoxicological and environmental impacts of plastics: emerging evidences and future challenges”



Oral Presentations





Plastics & Environment, 4-5th June 2026, Milan



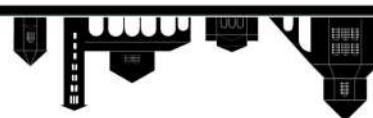
Keynote: Violette Geissen - Wageningen University & Research

Title: The hidden risk of agriplastics for food safety

Abstract:

Food demand has been strongly increasing during the past decades and is going to further increase. Urgent questions to be answered are: How to find a balance between yields optimization to feed the worlds increasing population, food safety and global health. Which are the needs and requirements for sustainable transition?

In this presentation I will focus on the role of agriplastics in agricultural production -curse or blessing? Agriplastics consist of different types of polymers and additives. The fate of plastic debris and the chemicals released in the process of degradation will be discussed and the resulting environmental and human exposure. The (not yet quantified) risk for ecosystem and human health will be discussed and requirements for regulations and sustainable solutions.



Invited Speaker: Veronica Nava – Università degli Studi di Milano - Bicocca

Title: Reframing plastics in freshwater ecosystems: from contaminants to drivers of biogeochemical and ecological processes

Abstract:

Plastics are now pervasive across all environments. Although numerous studies have investigated their chemical and toxicological effects, their role in ecological processes remains poorly understood. This contribution explores key mechanisms and presents results illustrating how plastics can influence the functioning of freshwater environments. A central mechanism is mediated by the “plastisphere”, defined as the community of autotrophic and heterotrophic microorganisms colonizing plastic surfaces and forming localized hotspots of biological activity capable of influencing ecosystem metabolism. Large-scale experiments conducted across broad geographical gradients show that the plastisphere enhances substrate availability for bacteria and microalgae, effectively acting as a novel “floating-benthic” habitat. Plastisphere biodiversity appears primarily driven by local environmental conditions, suggesting opportunistic colonization processes. Effects on ecosystem metabolism vary among sites: in more eutrophic systems, positive values of net ecosystem production have been observed, indicating a shift towards autotrophy. These findings suggest a potential role of plastics in modulating carbon cycling and broader biogeochemical processes in lake ecosystems. Despite being carbon-based materials, plastics are not yet incorporated into conceptual or numerical models of lakes as dynamic systems of carbon transformation, degradation, and emission (“active pipes”). Their inclusion may be critical depending on system characteristics and sensitivity to carbon inputs. Through plastisphere-associated processes and the release of labile carbon, plastics can alter nutrient cycling, influence food-webs, and contribute to greenhouse gas emissions. Here, we provide a conceptual framework for explicitly integrating plastics into freshwater carbon cycling, highlighting their potential role as active components of biogeochemical pathways in aquatic ecosystems.



Influence of fragmentation techniques on the physicochemical properties and biotic aging of true-to-life microplastics

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Keywords: microplastics, true-to-life, biofilm, fragmentation, aging.

Associated conference sessions: 1, 2

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Micro- and nanoplastics have become significant environmental pollutants, posing potential threats to aquatic ecosystems and human health. Despite growing concerns, there is a lack of harmonized methods for accurately identifying and assessing the impact of these particles. A major challenge in developing more relevant test micro- and nanoplastics is finding processes that closely mimic their environmental counterparts. Current studies still predominantly employ pristine spherical micro- and nanoplastic particles (micro/nanobeads). To address this issue, studies are moving towards the generation and use of environmentally relevant “true-to-life” test materials, made following top-down fragmentation approaches. These efforts aim to assess and refine analytical protocols, build trustworthy databases, and move a step closer to addressing the gap in the nanotoxicology of environmental samples (Ducoli, 2025 a).

In this context, the objective of this study was to assess how diverse fragmentation methods might yield fragments with distinct physicochemical properties, and to evaluate how this in turn could influence the biotic aging of microplastics and biofilm formation. In particular, we explored and compared two commonly used mechanical fragmentation techniques for preparing true-to-life materials starting from common plastic items. We analysed the shape, morphology and size distribution of the fragments through optical imaging, changes in chemical nature through FTIR, and modifications in the structure and crystallinity by means of XRD measurements (Ducoli, 2025 b). Finally, we subjected true-to-life microplastics to biotic aging in stream water and analysed the biofilm formation.

The results showed that the morphological and structural characteristics of microplastics varied based on the fragmentation approach and this in turn affect the biofilm formation onto microplastic surface, in terms of amount and types of bacterial strains. Microplastics with rough surfaces developed

significantly more biofilm than those with smooth morphology but exhibited significantly lower chlorophyll-a content and extracellular polymeric substances. Furthermore, these differences in biofouling were reflected in the density changes after aging, with irregular microplastics having a lower density than smoother counterparts (Klun, Ducoli, 2026).

These findings highlight the importance of employing true-to-life materials with greater environmental relevance and strongly support the necessity of an in-depth characterization of each microplastic preparation to accurately correlate microplastic properties with their observed effects.

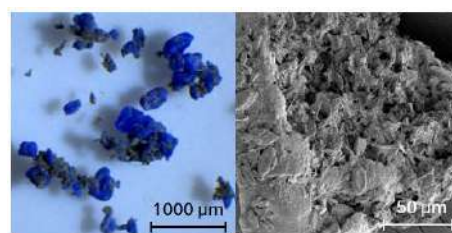


Figure 1. Optical microscopy image (left) and SEM image (right) of aged PS true-to-life microplastics.

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An integrated approach to assess the toxicity of accelerated aged microplastics from conventional and biodegradable polymers in *Daphnia magna*

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Keywords: weathering; microplastics; oxidative stress; multi-level approach

Associated conference sessions: 2

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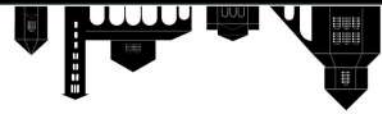
Parallel to conventional polymers, biodegradable one pose a significant risk to the environment when improper end-of-life management leads to their release into environment. Upon entering the natural environment, plastic items whether derived from conventional or biodegradable polymers are subjected to different weathering mechanisms which can lead to the production of the so-called weathered microplastics (wMP; Liu *et al* 2020). The physicochemical characteristics of wMP deviate significantly from those of virgin polymers, potentially exacerbating their toxicity to biological systems. Thus this study was aimed at evaluate the potential toxicity induced by the exposure to wMP obtained from objects made of conventional (polystyrene - PS and polyethylene - PE) and biodegradable (polylactic acid - PLA and polybutylene adipate terephthalate - PBAT) polymers towards *Daphnia magna* as a model organism. WMP were generated from previously obtained microplastics subjected to simulated solar radiation within a solar box, following the ISO 4892-2 protocols. A 21-days exposure was conducted using three concentrations (0.125, 1.25, and 12.5 µg/mL) of weathered PS-MP, PE-MP, PLA-MP or PBAT-MP. To investigate the adverse effects an integrate approach was applied focusing on endpoints coming from different level of the biological hierarchy such as: sub-individual, individual and population level. Sub-individual endpoints focused on oxidative stress (activity of antioxidant and detoxification enzymes and lipid peroxidation) and energy (protein, carbohydrate and lipid content) biomarkers. At individual level the potential changes in body growth and swimming activity were investigated, while as endpoint for population level reproductive effort was assessed. Our results showed that the exposure to wMPs obtained

from both conventional and biodegradable objects triggered biological responses across every investigated level of the biological hierarchy. In detail, only PS and PE wMP lead to negative effects at sub-individual and individual level with an alteration of the oxidative status, energy reserves and swimming activity, while all polymers lead to an effect at population level. Indeed, interestingly, the most pronounced biological responses were recorded regarding reproductive effort. The data revealed that PS and PLA exposure promoted an increase in the newborns, whereas PBAT led to a reduction. PE, however, exhibited no significant influence. Finally, the application of the Integrated Biomarker Response index (IBRv2; Sanchez *et al* 2013) highlighted that conventional polymers and specifically weathered PE demonstrated the most severe toxicological impact surpassing the values recorded for the biodegradable polymers.

These results highlighted the importance of using an integrated approach while investigating the potential negative effects induced by these contaminants and suggest the necessity to study in-depth the toxicity of wMPs.

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Breaking plastic, breaking balance: multi-level effects of mulches on terrestrial isopods

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Keywords: mulch, biofragmentation, soil contamination, woodlice, behavioural effects.

Associated conference sessions: 2

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Plastic mulch debris accumulates in agricultural soils worldwide, posing a potential threat to soil function. Here, we investigated the response of the detritivore *Porcellionides pruinosus* (woodlice) to black fossil-based (LDPE 0.1 % w/w) and black biodegradable (MaterBi® 0.06%) mulch strips to test the hypothesis that woodlice contribute to the generation of secondary plastic fragments by shaping ecological traits. Woodlice were further exposed to negative controls (no strips) and positive controls (strips of transparent LDPE, and black paper) to compare material- and color-dependent differences in consumption and debris production. Treatments included 10 strips per material (Fig. 1a), simulating 40% soil surface coverage (Hann et al., 2021). Ten adults per replicate (n = 10) were added in each treatment and 400 mg of baker's yeast was supplied across all conditions. Experiments ran for 7 and 14 days at 20 °C under a 16:8 h light:dark photoperiod.

Woodlice as vector of plastic pollution: shredding of the strips results in higher consumption of black paper (6-23 % debris loss) > MaterBi® (3-5 %) > LDPEs (< 1%), supporting the role of detritivorous degradation which is driven by material rather than color (Fig. 1b). Evidence of plastic ingestion in faecal pellets (Fig. 1c) was confirmed by Raman spectroscopy (Fig. 1d).

Effects on multilevel ecological traits: LDPE affected significantly behavioural traits at the population level, reducing gregariousness (Federico et al., 2024) and food consumption, decreasing individual physiological and metabolic traits. MaterBi® reduced gregariousness and food consumption at population level, but it did not affect physiological and metabolic traits, suggesting that the strips acted as an alternative food source in woodlice. Positive controls confirmed a harmful effect on ecological traits in the case of transparent LDPE, while black paper strips did not induce negative effects. Multivariate analysis of responses based on ecological

traits confirmed that fossil-based mulches were found to be more harmful than MaterBi® (F=2.99, p=0.021, R² = 0.15, PERMANOVA). However, both mulches altered population gregariousness, highlighting a risk to relevant population-level ecological traits.

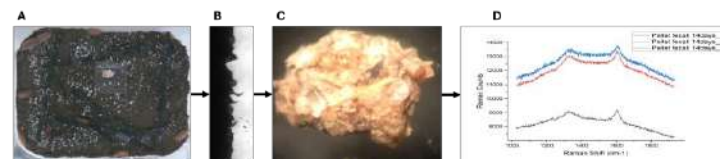


Fig 1. a) Detail of arena for the ecotoxicological bioassay on woodlice. b) Evidence of debris's shredding on LDPE strips. c) Microplastics of LDPE in fecal pellets. d) Detection of LDPE in fecal pellets by Raman spectroscopy.

It is concluded that woodlice produce secondary plastic from mulches, leading to significant changes in ecological traits, with significant modulation observed on gregarious behaviour. These outcomes raise questions about the long-term effects of plastic mulches on detritivore populations in agroecosystems and a more sustainable management of these plastic debris is mandatory.

This work was supported by Progetti di Ricerca di Interesse Nazionale (PRIN 2022), NANOpastics Toxicity Evaluation and Risk (management) in teRrestrial Agro-Ecosystems (NanoTERRAE).

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Impact of leachates from in-field collected plastics on aquatic organisms

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Keywords: Ecotoxicity, marine pollution, environmental plastics, additives, chemistry.

Associated conference sessions: 2

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In the present study carried out in the frame of the European JPI Ocean project Response (Towards a risk-based assessment of microplastic pollution in marine ecosystems), we evaluated the ecotoxicological assessment of leachates from in-field collected plastics on aquatic organisms (Fig.1). Leachates were obtained from micronized beached plastics collected in the Mediterranean Sea and Atlantic Ocean. The impact of leachates was assessed by using a multidisciplinary approach. Chemical analysis and ecotoxicological tests on aquatic vertebrates and invertebrates were performed on leachates from several plastic categories, including bottles, pellets, hard plastic (HP) containers, fishing nets (FN) and rapido trawling rubber (RTR). The bacteria *Alivibrio fischeri*, the early stages of the crustaceans *Amphibalanus amphitrite* and *Acartia tonsa*, the rotifer *Brachionus plicatilis*, the embryos of the sea urchin *Paracentrotus lividus*, the ephyrae of the jellyfish *Aurelia* sp. and the larvae of the medaka *Oryzias latipes* were exposed to different concentrations of leachates to evaluate both lethal and sub-lethal effects. Chemical analyses revealed the presence of thirty-one additives identified in the plastic leachates; benzophenone, benzyl butyl phthalate and ethylparaben were present in all leachates. Ecotoxicity of leachates varied among plastic categories and areas, being RTR, HP and FN more toxic than plastic bottles and pellets to several marine invertebrates. The ecotoxicological results based on 13 endpoints were elaborated within a quantitative weight of evidence (WOE) model, providing a synthetic hazard index for each data typology, before their integration in an environmental risk index. The WOE assigned a moderate and slight hazard to organisms exposed to leachates of FN and HP collected in the Mediterranean

Sea respectively, and a moderate hazard to leachates of HP from the Atlantic Ocean.

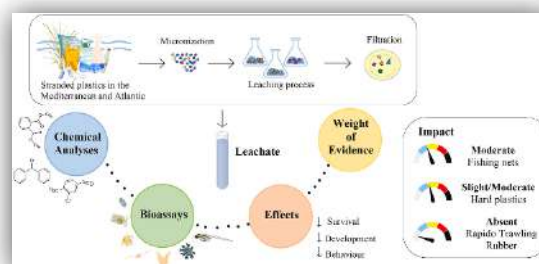


Figure 1. Summary of the experimental set up and main findings.

No hazard was found for pellets, bottles and RTR.

These findings suggest that an integrated approach based on WOE on a large set of bioassays is recommended to get a more reliable assessment of the ecotoxicity of beached-plastic leachates. In addition, the additives leached from FN and HP should be further investigated to reduce high concentrations and additive types that could impact marine ecosystem health.

This work was supported by EU JPI Ocean Response project, Grant n. MICROPLASTICC18_00042.

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Genome-scale transcriptional and metabolic profiling uncovers *Rhodococcus*-mediated polyethylene biodegradation pathways

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Keywords: plastic biodegradation, polyethylene, *Rhodococcus*, transcriptomics, oxidative enzymes.

Associated conference sessions: 2

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Polyethylene (PE) is the most widely produced synthetic polymer and poses significant environmental challenges due to its strong resistance to biodegradation. Understanding microbial mechanisms capable of transforming PE is therefore essential to address the environmental impact of plastic.

Among bacteria, members of *Rhodococcus* genus are notable for their remarkable metabolic versatility and their ability to degrade a wide range of contaminants, plasticizers, and polymers.

Rhodococcus opacus R7 represents a particularly promising model, as it grows on untreated PE as the sole carbon and energy source within a few days. Previous RNA-seq analyses, performed during the early stages of PE biodegradation, revealed the up-regulation of several oxidoreductases, including three laccase-like multicopper oxidases (*LMCO1*, *LMCO2*, and *LMCO3*), an alkane monooxygenase (*alkB*), and a cytochrome P450 hydroxylase (Zampolli et al. 2021; Zampolli et al. 2023).

This study aims to elucidate the molecular mechanisms underlying PE biodegradation through an integrated transcriptional and metabolic approach.

Physiological parameters and gene expression profiles were monitored for up to 28 days under different polymer exposure conditions. Cultivation strategy significantly influenced the bacterial response. A 0.4% PE fed-batch supply promoted higher biomass production than the 1% single-dose PE condition. Pre-cultivation on PE induced growth slowdown and increased intracellular lipid accumulation, indicating metabolic stress. Extracellular laccase activity detected during incubation suggests that oxidative processes initiate polymer activation outside the cell. Growth on UV-oxidized PE resulted in higher biomass production

but did not increase laccase activity; however, extracellular lipase activity was detected.

PE oxidation products detected by GC-MS vary compared to abiotic samples: fixed-dose PE favored accumulation of carboxylic acids and medium- to long-chain alkanes, whereas fed-batch PE produced a heterogeneous mixture, including alcohols and ketones.

Gene expression analyses revealed a coordinated activation of oxidative enzymes during PE exposure. Multiple *LMCOs*, *alkB*, and P450 hydroxylases were differentially up-regulated depending on polymer availability and growth stage, indicating a temporally regulated response. The fed-batch condition also showed stronger *LMCO* activity and a broader transcriptional response than the 1% single-dose PE condition. Moreover, long-chain *n*-alkanes further stimulated subsets of PE-responsive genes, acting as metabolic inducers.

Overall, these findings support a multi-step biodegradation model in which extracellular laccases initiate PE oxidation, generating oxidized intermediates subsequently processed by intracellular oxygenases. This integrated view provides new insights into microbial polyethylene transformation and contributes to the development of biologically driven strategies for plastic waste valorization.

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Session 2 – “Ecotoxicological and environmental impacts of plastics: emerging evidences and future challenges”



Poster





Beyond pure polymer: the Role of Additives in ecotoxicity of PEG-based Pharmaceuticals on *Danio rerio*

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Keywords: water-soluble polymers, plastics, multitier approach, zebrafish, environmental contamination

Associated conference sessions: 2 - Ecotoxicological and environmental impacts of plastics: emerging evidences and future challenge

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Water-soluble polymers (WSPs) are widely used in industrial, medical, and consumer applications. Their large-scale production and the lack of specific regulatory frameworks result in their continuous and uncontrolled release into the environment, especially aquatic ecosystems, raising concerns about potential risks to organisms and human health [1]. Traditionally, WSPs have been considered environmentally safe due to their high molecular weight, which was assumed to limit cellular uptake, and to the results from standard apical (eco)toxicological assays, measuring EC₅₀, NOEC, and LOEC. However, increasing evidence indicates that WSPs can induce sub-lethal effects in aquatic organisms, although most studies have focused on pure polymers, neglecting the complexity of commercial formulations actually entering the environment. Notably, commercial WSP-based products rarely consist of WSPs alone, but typically include additives that may significantly alter environmental fate and (eco)toxicity. Addressing this gap, our previous works focused on the ecotoxicological assessment of commercial PVA-based products at environmentally relevant concentrations and identified additives as the main drivers of toxicity [2].

Among WSPs, polyethylene-glycol (PEG) is one of the most widely used, particularly in pharmaceutical formulations, such as laxatives, which often contain high-molecular-weight PEG with eventual presence of additives [3]. This study aims to investigate the potential effects of two formulation of the same PEG based-laxative: (i) pure PEG-4000, and (ii) PEG-4000 (5 g in 10 mL) dissolved in purified water and combined with two additives (potassium sorbate and citric acid). *Danio rerio* embryos were exposed to both formulations at equivalent PEG concentration of 0.1 mg/L. A multitier approach was applied to assess effects at molecular, cellular, physiological, and organism levels, including proteomics, biomarkers of oxidative stress and neurotoxicity, cardiac activity,

morphometric parameters, spontaneous coil-tailing activity, and swimming behaviour.

At the cellular level, reactive oxygen species (ROS) production and ethoxyresorufin-O-deethylase (EROD) activity were significantly ($p < 0.05$) reduced only in embryos exposed to PEG+additives. In contrast, cardiac activity exhibited divergent responses, with a significant decrease in embryos exposed to PEG alone, but a significant increase in PEG+additives. Although some endpoints are still under analysis, these preliminary findings support the hypothesis that additives in commercial WSP-based formulations play a key role in modulating, and potentially driving, the toxicity of WSPs. Overall, this study highlights the importance of considering whole product formulations in ecotoxicological risk assessment of WSPs.

This work was supported by Fondazione Cariplo 2023-2677.

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Impact of Polyethylene Terephthalate Microplastics on Rumen Activity

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Keywords: Microplastics, Polyethylene terephthalate, Ruminal degradability, Ruminal microbiota.

Associated conference sessions: 1

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Microplastics (MPs) are increasingly detected in agricultural systems and livestock feed, raising growing concerns regarding their potential impact on ruminant digestive processes (Khan et al., 2024). This study aimed to evaluate the effects of polyethylene terephthalate (PET) MPs on the rumen degradability of the corn silage (CS) and on rumen microbiota, using an *in vitro* rumen simulation system. Corn silage samples were collected from three farms and incubated with buffered rumen fluid obtained from bulls in the presence of PET MPs at concentration of 0, 5, and 10 g/L. The experiment was conducted in three independent runs, with eight replicates of CS per run.

The results demonstrate that only the highest PET MP concentration significantly reduced crude protein degradability (CPdeg), with a decrease of 10% compared to control. (Table 1). These findings are consistent with previous reports highlighting the detrimental effects of PET MPs on ruminal protein utilization in hay and concentrate (Tassone et al., 2024; Abid et al., 2025). In contrast, no significant effects were observed on dry matter (DMdeg), neutral detergent fiber (NDFdeg), suggesting a selective impact on proteolytic activity.

Table 1. Effect of polyethylene terephthalate microplastics on ruminal degradability of corn silage (%)

	0 g/L	5 g/L	10 g/L
DMdeg ¹	62.8	64.2	65.7
CPdeg ²	55.0 ^a	53.2 ^{ab}	50.2 ^b
NDFdeg ³	51.1	50.8	53.9

¹DMdeg: dry matter degradability, ²CPdeg: crude protein degradability, ³NDFdeg: neutral detergent fiber degradability.

Metataxonomic analysis revealed no significant differences in alpha diversity indices or overall microbial community structure in agreement with

previous studies suggesting that polyester MPs may alter microbial functionality without substantially affecting diversity (Chang et al., 2024). This suggests that PET MPs may interfere primarily with enzymatic processes, particularly proteolysis, rather than inducing broad microbial dysbiosis.

These findings highlight the potential risk of PET MPs on rumen efficiency, particularly nitrogen utilization, thereby negatively affecting the sustainability and profitability of ruminant production systems.

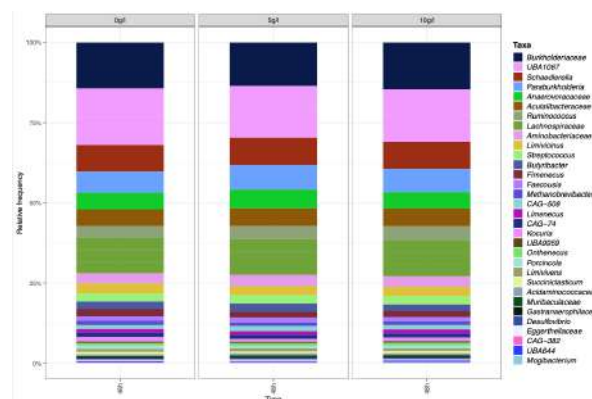
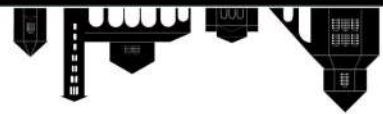


Figure 1. Rumen microbiota after 48 h of *in vitro* incubation of corn silage samples with increasing concentrations of PET microplastics (0, 5, and 10 g/L).

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Microplastics as vectors of organic contaminants accumulated in aquatic environments: chemical characterization and endocrine–metabolic effects in fish

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Keywords: microplastics, PFAS, PAHs, pesticides, endocrine disruption.

Associated conference sessions: 1, 2

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Microplastics (MPs) are increasingly recognized as vectors of organic contaminants in aquatic environments. In this study, a mixture of polymer particles (PS, PE-HD/LD and PP) was deployed in situ within the aquatic environment for one month using incubation devices anchored to the riverbed, in order to simulate environmental exposure and assess their capacity to adsorb persistent organic pollutants under realistic conditions. Following exposure, MPs were recovered and analysed to investigate the adsorption of PFAS, PAHs and pesticides, as well as their potential biological effects through an integrated approach combining chemical analysis, *in silico* prediction and gene expression profiling.

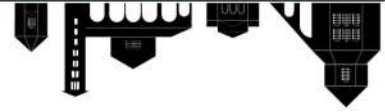
Chemical characterization revealed the presence of PFAS, mainly PFOA, PFHpA and PFHxA, although at low concentrations, together with PAHs such as acenaphthylene, fluorene and benzo(b)fluoranthene, and pesticides including hexachlorobenzene and MOCAP. Overall concentrations were relatively low, confirming that MPs can adsorb multiple contaminant classes even at trace levels. Adsorption patterns varied among polymers, reflecting differences in physicochemical properties such as hydrophobicity and surface structure.

Molecular docking analysis indicated that several contaminants show moderate to high binding affinity toward nuclear receptors including AhR, ER α / β , RXR α and PPAR α , suggesting a potential for endocrine and metabolic disruption.

Consistent with *in silico* predictions, gene expression analysis showed a significant up-regulation of PPAR α , RXR α , AhR and ER α in organisms exposed to environmentally conditioned MPs, accompanied by increased expression of vitellogenin (VTG), a biomarker of estrogenic activity. Conversely, a down-regulation of

lipid metabolism-related genes (APOA-1 and HL) was observed, together with an increase in bile acids, indicating a possible alteration of hepatic lipid homeostasis.

These results highlight the dual role of MPs as carriers of bioactive contaminants and modulators of molecular pathways related to endocrine and metabolic functions. The study provides evidence that even low levels of adsorbed pollutants can induce significant biological responses, supporting concerns about the ecotoxicological implications of MPs in aquatic ecosystems.



Multigenerational effects of fossil-based versus recycled nylon on benthic freshwater macroinvertebrates

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Keywords: polyamide6, *Chironomus riparius*, regenerated plastics, ecotoxicology, freshwater.

Associated conference sessions: 2

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Synthetic fibres account for more than 70% of global textile production (Mossotti et al., 2022) and are the most common form of microplastics (MPs) detected in glacier and freshwater environments (Crosta et al., 2025; Sbarberi et al., 2024).

Although recent European regulations promote the use of recycled plastics, experimental evidence comparing the biological effects of recycled and virgin MPs remains limited.

To fill this gap, we performed a multigenerational ecotoxicological test by comparing virgin polyamide 6 (PA6) with regenerated polyamide 6 (Econyl®) microfibres of the same size (200 µm × 40 µm). Two consecutive generations of *Chironomus riparius* were exposed to the mean concentration of MPs reported in literature for the Italian river sediments (2 mg of MPs items/150 d dry sediment). The test was conducted according to the OECD 233 guidelines, coupled with the analysis of oxidative stress biomarkers (MDA and PCC), currently in progress.

In the first generation, both polymers exerted comparable impacts on insect emergence (Figure 1A), fecundity, and fertility. Although virgin PA6 delayed developmental timing relative to the control, its effects did not differ significantly from those of Econyl®. Conversely, responses became more pronounced in the second generation (Figure 1B): PA6 induced severer impairments in emergence while developmental responses exhibited greater consistency.

Finally, regenerated nylon microfibres exhibited effects comparable to or lower than those of fossil-based fibres across second-generation exposure on life cycle. Based on these preliminary results, the two polymers, despite being considered physico-chemically

identical, appear to exert different effects on freshwater insects.

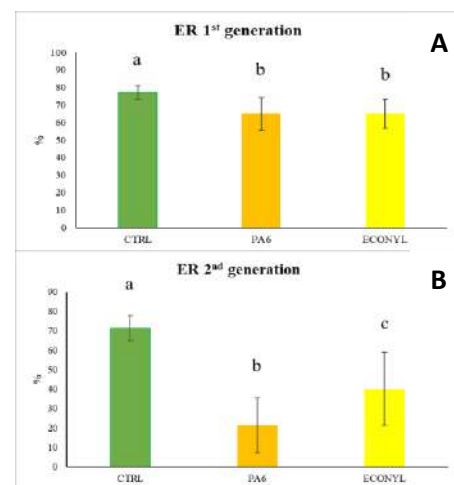
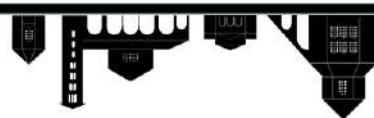


Figure 1. Emergence rate (ER) of *C. riparius* exposed to fossil-based PA6 and Econyl® microfibres in the first (A) and second (B) generations. Different letters above the bars indicate significant differences ($p < 0.05$, ANOVA/Tukey).

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Biological effects of cellulose-based bioplastics leachates on adults *Mytilus galloprovincialis*

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Keywords: Bioplastics, Additives, Leachates, Biomarker, *Mytilus galloprovincialis*.

Associated conference sessions: 2

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When not properly managed, plastics can enter the environment, where they are subjected to both biotic and abiotic degradation processes that promote the release of chemical compounds known as additives. These organic and inorganic compounds are incorporated during polymer production to enhance material performance and properties, and most of them are not covalently bound to the polymer matrix. (Gunaalan et al., 2020).

Several additives, including phthalates and brominated flame retardants, can cross biological membranes and have been associated with mutagenic, carcinogenic, and endocrine-disrupting effects in living organisms (Costa et al., 2023).

The introduction of bioplastic polymers as alternatives to conventional plastics does not mitigate these concerns, as bioplastics rely on the same class of additives, thereby posing potential risks to both ecosystem and human health.

This study aimed to understand the biological impact of additive mixtures derived from single-use items made of cellulose on adult mussels, *Mytilus galloprovincialis*. A suite of biomarkers was evaluated: stability of lysosomal membranes (LMS) in hemocytes by neutral red retention assay (NRR), accumulation of lipofuscins (LF) and neutral lipids (NL), lysosomes:cytosol ratio (LYS/CYT), and LMS in the digestive gland by microscope observation; enzyme activity of glutathione-S-transferase (GST), catalase (CAT) and acetylcholinesterase (AChE) by spectrophotometric analysis.

The samples analysed were cups made of paper and polylactic acid (C), and two different types of paper plates (P1 and P2). Selected materials were ground into small pieces and individually added to artificial sea water at a final concentration of 80 g/L (w/V). Samples were placed in a rotating incubator (125 rpm) at RT (~20 °C) for 14 days in the dark. Leachates were then passed through a sterile 0.22 µm filter to eliminate particles

and kept in darkness at -20 °C until use (Capolupo et al., 2020). Plastic items and additives were analysed for organic and inorganic chemicals. In particular, organic additives of the paper samples included abietic, dehydroabietic, pimaric, and isopimaric acids.

Biological effects of 0.6% leachate concentrations were assessed after *in vivo* exposure of mussels for 7 days. The analysis of LMS in haemocytes showed a significant reduction of neutral red retention time (NRR) in mussels exposed to P1 and P2 leachates. Similar effects were observed in mussels exposed to conventional plastic and bioplastic leachates (Capolupo et al., 2021, 2023). C, P1 and P2 leachates, showed significant increases in the LYS/CYT ratio and lipofuscin accumulation.

Overall, the results highlight that cellulose-based materials can release additives even after a short leaching period, significantly affecting the lysosome compartment of mussel, and potentially impacting marine ecosystems across multiple levels of biological organization.

This work was supported by PRIN2022 YHXCWP "Adverse impacts of plastic additive mixtures in the marine environment: from molecules to whole organism physiology".

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Chemical characterization of leachates from cellulose-based bioplastics and their biological effects on larvae of *Mytilus galloprovincialis*

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Keywords: Bioplastics, Additives, Embryotoxicity, Leachates, Mussels

Associated conference sessions: 2

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As one of the most widely produced and utilized materials, plastics pose significant environmental concerns when improperly managed at the end of their life cycle. These concerns include their occurrence in the environment, the leaching of additives, and fragmentation into micro- and nano-plastics (Williams & Rangel-Buitrago, 2022). Bioplastics, introduced as an alternative to conventional plastics, may be subject to similar issues, compounded by their often inferior mechanical properties. To address these limitations, higher amounts of organic and inorganic additives are frequently incorporated, potentially exacerbating environmental risks (Chen, 2022).

Following the implementation of the EU Directive 2019/904 Single-Use Plastic (SUP), Italy has progressively replaced single-use items made of conventional plastics with bioplastics such as starch blends (SB), polylactic acid (PLA), polybutylene succinate (PBS), and polybutylene adipate terephthalate (PBAT). More recently, these materials have been replaced with cellulose-based materials.

This study aimed to advance understanding of the impact of additive mixtures released from cellulose-based single-use items on marine ecosystems. The organic and inorganic additives present in these materials, as well as in their leachates, were characterized and quantified (Crema et al., 2024). Their biological effects were then assessed on *Mytilus galloprovincialis*, focusing on fertilization success and embryonic development.

Commercially available items were analysed: cups made of paper and polylactic acid (C), and two different types of paper plates (P1 and P2). Leachates were produced in artificial seawater (ASW), as previously described (Capolupo et al., 2020). Briefly, selected materials were ground into <5 mm pieces and individually added to artificial seawater at a final concentration of 80 g plastic/L. Samples were placed in

a rotating incubator for 14 days in the dark. Leachates were then passed through a sterile filter to eliminate particles and kept at -20 °C until use (Capolupo et al., 2020).

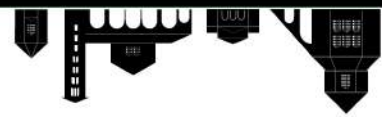
Plastic items and leachates were subjected to chemical characterization for organic and inorganic additives. The presence of additives commonly used to produce both plastic and bioplastics polymers were found in leachates; all items contained abietic acid derivatives, known to be used to make paper waterproof.

Biological effects of 11 different leachate concentrations were assessed *in vitro*, ranging from 100% (no dilution) to 0.6% (167 times dilution). No significant effects were noted on fertilization rate (except 100% concentration). At 48-hour exposure of embryos to the leachates caused a significant reduction of normally developed larvae (i.e. showing the typical "D-shaped" veliger stage) at leachate concentrations above 60% (C) and 20% (P1 and P2). These results underline that leachates from cellulose-based items can affect early life stages of marine mussels, similarly to those from conventional plastics (Capolupo et al., 2020)

This work was supported by PRIN2022 YHXCWP "Adverse impacts of plastic additive mixtures in the marine environment: from molecules to whole organism physiology".

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Exposure to polyethylene terephthalate (PET) nanoplastics induced oxidative stress and altered swimming behaviour in *Daphnia magna*

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Associated conference sessions: 2

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Nanoplastics (NPs) are increasingly recognized as a major emerging concern in plastic pollution due to their strong potential to interact with the biota and cause harmful effects (Thakur et al., 2025; Bratovcic, 2019). While several studies have reported the toxicity of polystyrene NPs in aquatic species, there is still limited knowledge regarding NPs derived from other polymers, such as polyethylene terephthalate (PET).

In this context, the present study examined the short-term toxicity of PET nanoplastics (PET-NPs; 50 nm) in the freshwater cladoceran *Daphnia magna* using a multi-level approach. Newborn individuals were exposed for 120 hours to three concentrations of PET-NPs (0.125, 1.25, and 12.5 µg/mL), and responses were assessed at both biochemical and behavioural levels. PET-NPs were detected in the digestive tract after just 24 hours of exposure.

Exposure to the highest concentration induced oxidative stress, as shown by increased antioxidant enzyme activity and enhanced lipid peroxidation. Additionally, PET-NPs affected the daphnids' energy metabolism, leading to a significant increase in carbohydrate levels, which may indicate a shift in energy allocation under stress. Behavioural changes were also observed, with temporary alterations in swimming patterns, specifically reduced movement duration and increased angular velocity after 24 hours, followed by a return to normal at later time points (Figure 1), suggesting a possible adaptive response.

Overall, these results show that short-term exposure to PET-NPs can cause sublethal effects in *D. magna*, reinforcing concerns about NPs toxicity and highlighting the need for further research to better understand their ecological risks in freshwater environments.

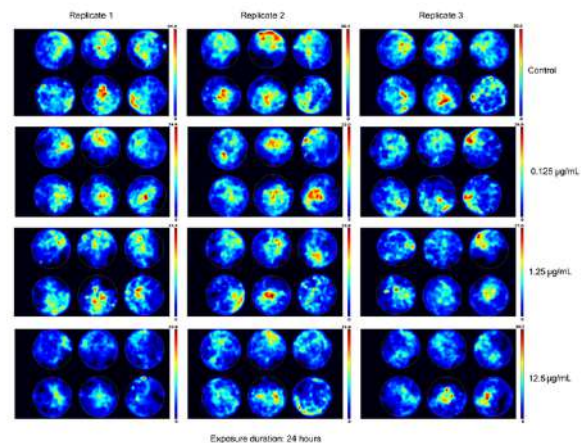


Figure 1. Heatmap of *D. magna* swimming activity exposed to PET-NP at concentrations of 0.125, 1.25 and 12.5 µg/mL after 24 h of exposure. Data represent three replicates for each concentration, collected during a 5-min observation period.

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From Material to Organism: A Comprehensive Pipeline for “True-to-Life” Micro- and Nanoplastics Characterization and Biological Interaction

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Understanding the behavior, fate, and impacts of micro- and nanoplastics (MNPs) requires the availability of test materials that accurately reproduce the physical and chemical properties of particles found in the environment. However, most currently used test materials are artificially synthesized and fail to reflect the heterogeneity and complexity of environmental plastics. In this study, realistic MNPs were produced and comprehensively characterized to provide reliable materials for ecotoxicological and environmental assessments. Expanded polystyrene (EPS) was selected as a model polymer because of its extensive use in packaging and construction and its frequent detection in terrestrial and aquatic ecosystems.

EPS-MNPs were generated through cryogenic mechanical fragmentation of construction-grade EPS, a process that allowed to reproduce natural weathering and mechanical stress. A multi-technique analytical approach, combining optical and electron microscopy (SEM), atomic force microscopy (AFM), micro-FTIR, micro-Raman spectroscopy, thermogravimetric analysis (TGA), and micro-X-ray diffraction (micro-XRD), was employed to evaluate morphology, chemical composition, and structural integrity. These analyses confirmed the preservation of the polymer identity while revealing extensive heterogeneity in particle size, shape, surface roughness, and degradation features, thus mirroring environmental diversity.

To further enhance environmental relevance, EPS specimens collected during cleanup campaigns

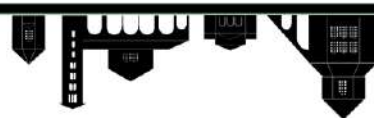
were fragmented and incorporated into the sample set. To investigate their potential biological effects, the resulting particles were subsequently used in toxicity tests on filter-feeding biota (mussels), assessing uptake, accumulation, and egestion dynamics under controlled laboratory conditions.

These true-to-life EPS-MNPs represent a valuable resource for realistic ecotoxicological testing and improved risk assessment. Their environmentally relevant characteristics allows for a more suitable development of harmonized experimental protocols and for studies on degradation pathways, contaminant adsorption, and trophic transfer.

This work was supported by the PRIN 2022: PLASTACTS-Assessment of nano/microplastics impacts (No. 202293AX2L, CUP D53D23009050001). SB, AF, DS, MGD, PGG also acknowledge funding from the NextGeneration EU MUR-PNRR project SAMOTHRACE (ECS00000022). KA acknowledges funding from the PRIN-FLASH2D (2022FWB2HE). S.D., P.G.G., M.C, S.F. also acknowledge the COST Action CA20101 PRIORITY.

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Leachates from paper-based bioplastic items induce shifts in microbiome composition of different tissues of marine mussels

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Keywords: biodegradable plastic, leachates, mussel, immunity

Associated conference sessions: 2

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The environmental concerns on plastic pollution include the potential impact of different plastic particles on the microbiota associated with different hosts (Chen et al., 2025). Recent data indicate that also plastic leachates (PL), containing mixtures of additives released during degradation of plastic items, can affect marine microbial communities (Maday et al., 2025). However, no information is available on the potential impact of PL on the host microbiome in marine species.

In this work, the potential impact of leachates from different types of cellulose-based bioplastic items on the microbiome associated with different tissues of the model marine invertebrate, the bivalve *Mytilus galloprovincialis*, was evaluated.

PL were obtained from 3 types of 2nd generation bioplastics 1) Plates: paper (P); 2) Plates: paper (P2); 3. Glasses: paper and polylactic acid (P/PLA). Plastics (80 g) were cut into 5 mm pieces, added to 1L of artificial seawater, and placed in a rotating incubator in the dark, at room T for 14 days. Samples were filtered and stored in the dark at -20°C until use. Adult mussels were exposed to different PL (4 days, 0.1% dilution). At the end of exposure, DNA was extracted from samples of hemolymph, gills and digestive gland and microbiome composition was evaluated by 16S rRNA gene amplification and sequencing (Auguste et al., 2020).

Results: exposure to different PL induced shifts in abundance of different bacterial taxa, from the phylum to the genus level. Members of Arcobacteraceae and Vibrionaceae were among the most modulated in all tissues. The effects were more evident in the digestive gland, also showing increases in Mycoplasmataceae (Fig.1).

To our knowledge, these are the first data on the effects of PL on the microbiome of marine bivalves. These data support the hypothesis that leachates from cellulose-based bioplastic can have a significant impact on microbial communities associated with different

tissues of the bivalve host, with increases in members of opportunistic and potentially pathogenic bacteria, leading to possible consequences on mussel health and survival. This information is crucial for understanding the environmental implications of the improper disposal of this increasingly prevalent biomaterial and its degradation products.

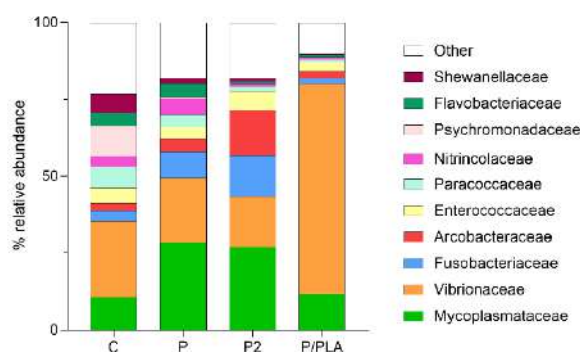


Fig. 1 - Relative abundances of microbial communities in *M. galloprovincialis* digestive gland after 96 h exposure to different PL at the family level (% of 10 top families).

This work was supported by PRIN2022 YHXCWP *Adverse impacts of plastic additive mixtures in the marine environment: from molecules to whole organism physiology*, Italian Ministry of Research (MUR).

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Impact of leachates from paper-based bioplastic items on immune function and oxidative stress biomarkers of marine mussels

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Keywords: biodegradable plastic, leachates, mussel, immunity

Associated conference sessions: 2

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Plastics are intentionally produced by mixing the polymers with a wide range of additives, in order to give the final product the desired properties. Since additives are generally not chemically bound to the polymer, they have the potential to leach out to the environment during the whole plastic life cycle. Plastic leachates (PL) thus result in mixtures of additives, many of which are listed as Emerging Contaminants-EC, i.e. substances with the potential to pose risks to the environment and human health, but not yet regulated (Gunalaan et al., 2020). Despite the increasing amount of data on the impact of plastic particles on aquatic biota, the issue of PL, in particular of those from biodegradable plastic, has been so far largely overlooked.

In this work, the potential impact of leachates from different types of bioplastic items was evaluated in the model marine invertebrate, the bivalve *Mytilus galloprovincialis*. These include 3 types of 2nd generation cellulose-based bioplastics: 1) Plates: paper (P); 2) Plates: paper (P2); 3) Glasses: paper and polylactic acid (P/PLA).

PL preparation: plastics (80 g) were cut into 5 mm pieces, added to 1L of artificial seawater, and placed in a rotating incubator in the dark, at room T for 14 days (Capolupo et al., 2020). Samples were filtered and stored in the dark at -20°C until use.

Adult mussels were exposed to different PL (4 days, 0.1% dilution). At the end of exposure, haemolymph immune parameters (lysosomal membrane destabilization-LMS, phagocytic activity, extracellular ROS and NO production, lysozyme release, and total bacterial load) were evaluated (Auguste et al., 2020). Biomarkers of oxidative stress and biotransformation (Catalase-CAT and GSH transferase-GST), and of metal exposure (metallothionein-MT) were also evaluated in gills and digestive gland.

Results: exposure to different PL affected all immune parameters. In particular, P2 and P/PLA

leachates induced strong hemocyte stress, resulting in higher bacterial load (Table 1). Significant effects were also observed on tissue CAT and GST activities, whereas the level of MT was unaffected.

Table 1. Effects of different bioplastic leachates on haemolymph immune parameters and bacterial load. * $p \leq 0.05$, ANOVA + Dunnett's post test

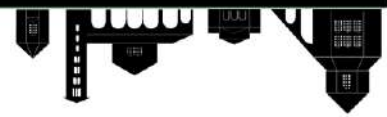
%	LMS	Phago	NO	ROS	Lyso	Bacterial load
P	-27*	-40*	+109*	+3	+109*	-81*
P2	-94*	-35*	+101	+2	+124*	+123
P/PLA	-97*	-34*	+79	-7	+22	+113

These data support the hypothesis that also leachates from cellulose-based bioplastic can have a significant impact on key marine invertebrate species, with possible consequences on mussel health and survival. Chemical analyses of these complex mixtures will help understanding the role of main components of each PL in determining the biological effects observed.

This work was supported by PRIN2022 YHXCWP *Adverse impacts of plastic additive mixtures in the marine environment: from molecules to whole organism physiology*, Italian Ministry of Research (MUR).

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Exploring the effects of microplastic leachates on *Porcellionides pruinosus* and *Folsomia candida*.

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Keywords: plastic leachate, soil, *Folsomia candida*, *Porcellionides pruinosus*, ecotoxicity.

Associated conference sessions: 2

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Plastic films are widely used in agriculture, particularly for mulching to improve crop yields. However, plastic mulches tend to fragment into microplastics (MP), potentially impacting edaphic organisms. To date, there is an important knowledge gap on the effects on soil fauna of compounds released by the leaching of mulches (Qi *et al* 2020, Büks *and* Kaupenjohann 2023).

The aim of the present study is to explore the effects of leachate derived from low-density polyethylene (LDPE) and polypropylene (PP), two of the most abundant constituents of mulching films, on different soil species. The leachates tested in this study originate from additive-free MPs that have been previously artificially photoaged to mimic outdoor exposure, to evaluate the toxicity of the plastic polymer leachate itself without additional contaminants (Isa *et al* 2025).

Avoidance tests, following and adapting the methodology of the standardized ISO guideline (ISO, 2011), have been conducted on *Folsomia candida* (springtail) and *Porcellionides pruinosus* (terrestrial isopods) at four increasing concentrations (from 0 to 200 mg/kg d.w). Since *P. pruinosus* displays a gregarious behavior to overcome dehydration, two different disaggregation indices (DI and DG) has been calculated to determine the potential infochemical disruption on aggregation behavior, following Federico *et al* (2024). The effects of MP leachate were analyzed using the Kruskal-Wallis test.

The avoidance tests with *F. candida* and *P. pruinosus* indicated that neither the type nor the concentration of MPs significantly affected avoidance behavior. Interestingly, disaggregation indices significantly exceeds the threshold of 0.5 at the concentration of 152 mg/kg for LDPE (DI, $p = 0.034$; DG: $p = 0.018$), and for PP (DI: = 0.048; DG: $p = 0.018$), indicating a pronounced disaggregation effect at this high concentration (Fig. 1).

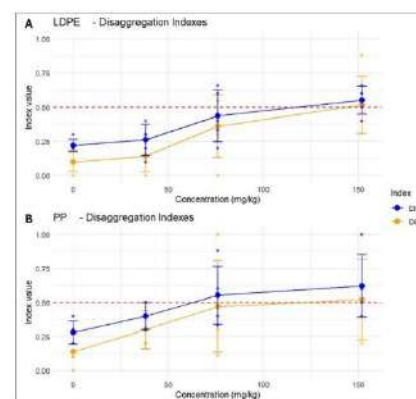


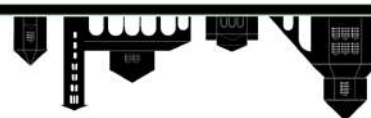
Figure 1. Disaggregation Indexes for different concentrations (0, 38, 76, and 153 mg/kg) of LDPE and PP. The red dashed line represents the 0.5 threshold.

Due to the observed effects, we suggest the potential sub-lethal impacts of additive-free MP leachates on the social behavior of edaphic soil species, underlining the need for further studies to better understand the long-term effects of plastic contamination on soil fauna in agroecosystems.

This work was supported by Progetti di Ricerca di Interesse Nazionale (PRIN 2022), NANOpastics Toxicity Evaluation and Risk (management) in teRrestrial Agro-Ecosystems (NanoTERRAE).

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Colloidal characterization of bio/eco-corona formation on nanoplastics

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Keywords: Colloidal characterization, Bio/eco-corona, Dynamic light scattering technique, Centrifugal liquid sedimentation technique, Nanoplastic.

Associated conference sessions: 2

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Micro-nanoplastics (MNPs) can alter their identity in exposure media through the formation of a matrix-dependent bio/eco-corona, driven by the interaction and physi-/chemisorption of biomolecules and natural organic matter on their surfaces (Zanoni, 2025; Placci, 2025). In environmental compartments, natural constituents adsorb onto particle surfaces, forming an eco-corona composed of metal ions, inorganic salts, natural organic matter, and persistent organic pollutants. Upon interaction with biological systems, these particles further evolve by binding biomolecules such as proteins, lipids, and nucleic acids. Understanding the evolution of particle properties after the formation of a corona is therefore key, as it governs the fate and behavior of MNPs, including distribution, transport, degradation, cellular uptake, interaction pathways, and toxicity in living organisms. Here, we investigate the formation of bio/eco-coronas on polystyrene (PS) and polyethylene terephthalate (PET) nanoplastics in various media, including biological fluids, a food matrix (milk), and ocean water (Figure 1).

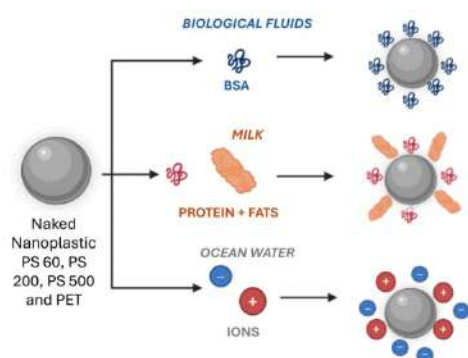


Figure 1. Plastics and exposure matrices.

To capture these effects, we employed a combined analytical approach based on Dynamic Light Scattering (DLS) and Centrifugal Liquid Sedimentation (CLS), evaluating their performance across different conditions. Our results highlight the limitations of DLS in complex matrices (e.g., milk), where background colloids easily mask the nanoplastic signal, whereas CLS provides improved sensitivity and enables the detection of size variations associated with corona formation.

Overall, the combined use of DLS and CLS allows for a more comprehensive characterization of corona-associated components, particle size evolution, and aggregation phenomena. These findings demonstrate that integrating complementary techniques is essential to reliably capture corona formation dynamics and should be considered a critical step to support the environmental risk assessment of nanoplastics.

This work was supported by the European Union – NextGeneration EU through the Italian Ministry of University and Research under PRIN 2022 PNRR "DOMANI", No. P2022SET7C.

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IMPACT OF MICROPLASTICS FROM FACE MASKS ON ZEBRAFISH EMBRYO DEVELOPMENT AND TOXICITY

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Keywords: *Danio rerio*, oxidative stress, microplastics, face masks

Session 2: Ecotoxicological effects, underlying mechanisms of action across biological levels

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Facemasks productions were increased to protect aerosol transmission of corona virus during COVID-19 pandemic, and their improper disposal becomes a challenge for the environment as a part of plastic pollution (Williams and Rangel-Buitrago, 2022). Billions of face masks have become a source of environmental pollution and microplastic degradation from face masks cause adverse effects on living organisms (Thakur et al., 2023). Microplastics can induce toxicity in zebrafish embryo development, thus, the aim of this study was to observe the adverse developmental effects in zebrafish exposed to facemasks fragments (Barari and Bonyadi, 2023). Face masks collected from natural environment were crushed to obtain two different concentrations of 10 mg/L and 100 mg/L respectively, and healthy *Danio rerio* embryos were exposed to these solutions for 96 hpf (hours post fertilization) to study the possible related developmental toxicity. According to OECD guidelines, every group was monitored at following points (24, 48, 72 and 96 hpf) to investigate hatching rate, survival rate, and possible morphological defects. At 96 hpf, there was no statistically relevant mortality, and normal hatching was observed in both exposed groups. Zebrafish after 96 hpf did not show morphological abnormalities in physical organs like head, body, somites, eyes, heart and tail. Ultimately, the oxidative stress pathway was investigated, and MDA levels appeared significantly increased in both experimental groups compared to control, with the highest level of lipid peroxidation observed in 100 mg/L exposed group, suggesting a dose depending on toxicity.

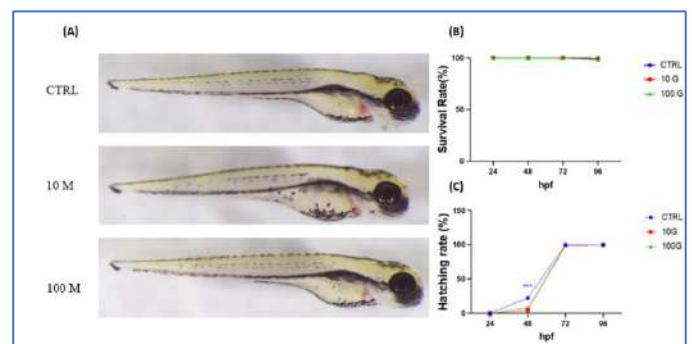


Figure 1- Morphological images of control group (CTRL) and zebrafish exposed to fragmented masks at 10mg/L (10 M) and 100 mg/L (100 M) concentrations (A); survival rate (B) and hatching rate (C).

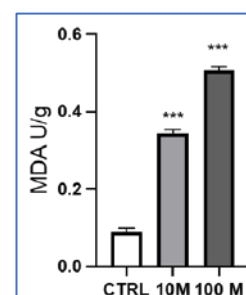
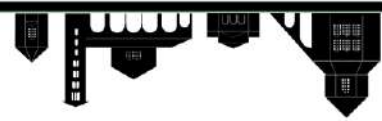


Figure 2- MDA content of larvae exposed to mask fragments 10 mg/L (10M), 100mg/l(100M).

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Investigating Roadside Soil Microbiomes: Metagenomic Analyses to Identify Taxa Driving Rubber Degradation

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Keywords: TRWPs, Metagenomics, Rubber Degradation, Microbial Consortia, Roadside Soil

Associated conference sessions: 2, 4

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The significant environmental accumulation of waste tyres and the release of significant amounts of particulate debris, predominantly tyre and road wear particles (TRWP) generated by the friction between tyres and road surfaces, pose a critical challenge. While biodegradation has been extensively studied for other recalcitrant polymers such as plastics, rubber has received little attention. Moreover, current research often focuses on individual rubber-degrading microbial strains, whereas the complexity of rubber suggests that efficient degradation requires synergistic interactions within microbial consortia. A broader overview of rubber degradation processes is therefore essential. In this work, we proposed a combined approach employing metagenomic sequencing alongside tests (plate isolation) on microbial consortia to explore the potential of both culturable and non-culturable, low-abundance microorganisms in rubber degradation.

We investigated this potential by enriching microbial communities derived from roadside soil collected from heavily trafficked road using rubber compounds as the sole carbon source. This selective pressure promoted the growth of rubber-degrading taxa. Subsequently, we utilized two metagenomic approaches - 16S rRNA gene sequencing and shotgun metagenomics - to characterize the taxonomic composition of the whole microbial communities from both the original soil and the enriched samples.

Comparative metagenomic analyses (16S rRNA gene sequencing and shotgun sequencing), demonstrating concordance between taxonomic and functional profiles, revealed significant shifts in microbial community structure and facilitated the identification of key taxa. This allowed us to assess the overall metagenomic divergence driven by the selective pressure of the enrichment conditions. By comparing microbial communities from heavily trafficked road

soils with those enriched under controlled, rubber-only incubations, this work provides novel insights into environment's responses to rubber pollutants and the microbial potential for their breakdown.

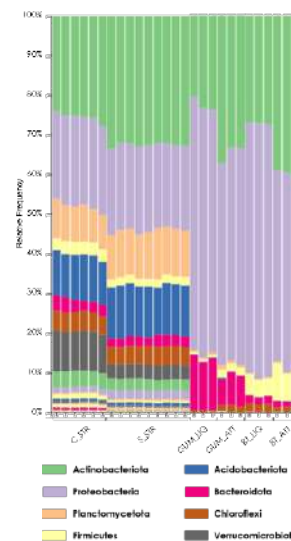


Figure 1. Taxonomic profiles of the soil and liquid samples at phylum level. Profiles include samples collected far from the street (C_STR), near the street (S_STR), and derived from the soil enrichment experiment. The last differentiate between attached (ATT) and planktonic (LIQ) microorganisms grown on either GUM or BT (Tread Compound) rubber films.

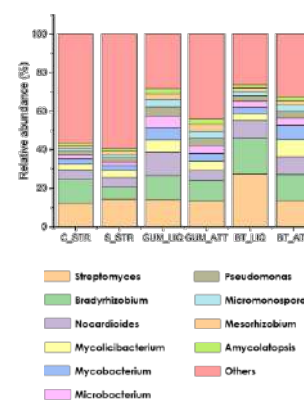


Figure 2. Taxonomic profiling of metagenomes across hierarchical ranks. Relative abundances are shown for each community. Percentages are grouped by the Top 10 most abundant taxa per rank, with all others collapsed into the "Other" category.

This work was supported by CORIMAV and partially by Fondo di Ateneo (University of Milano-Bicocca).



Combined Effects of Microplastic Contamination and Phosphorus Deficiency on Tomato Rhizosphere Dynamics

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Keywords: microplastic contamination, phosphorus deficiency, rhizosphere processes, root exudation

Associated conference sessions: 2

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Microplastic (MP) contamination is an emerging abiotic stress in terrestrial ecosystems (Bouaicha et al., 2022). However, the effects of combined MP and nutrient deficiencies remain poorly understood, particularly in relation to rhizosphere processes (Wang and Lambers, 2020). This study examines the combined effects of phosphorus (P) deficiency and MP contamination on tomato (*Solanum lycopersicum* L.) grown in soil, focusing on chemical and microbial dynamics in the rhizosphere and plant physiological responses (Pita-Barbosa et al., 2025). We hypothesize that the combination of stresses will modify root exudation, rhizosphere microbial communities, root nutrient content and photosynthetic parameters. Plants were cultivated under P deficiency and sufficiency with and without MP addition at 50 mg kg⁻¹. Tomato plants were grown for 30 days. At harvest, root exudates were collected via the hybrid soil-hydroponic method, photosynthetic parameters were evaluated via PhotosynQ and rhizosphere soil collected for DNA metabarcoding targeting bacterial 16S and fungal ITS regions. Root and shoot fresh and dry weights were assessed. Root exudates were analyzed for carboxylates using ion chromatography-mass spectrometry, as well as for total carbon via an elemental analyzer, protein, phenol and flavonoid concentrations content via colorimetric assays. Plant dry material was mineralized and analyzed via inductively coupled plasma mass spectrometry for elemental composition. This work highlights the importance of investigating how microplastics (MPs) interact with existing environmental stressors. Because MPs may exacerbate these stresses, understanding their combined effects is essential. The findings will provide new insights into ecosystem resilience, strengthen risk assessment frameworks, and inform more effective management and mitigation strategies for ecosystems exposed to multiple stressors.

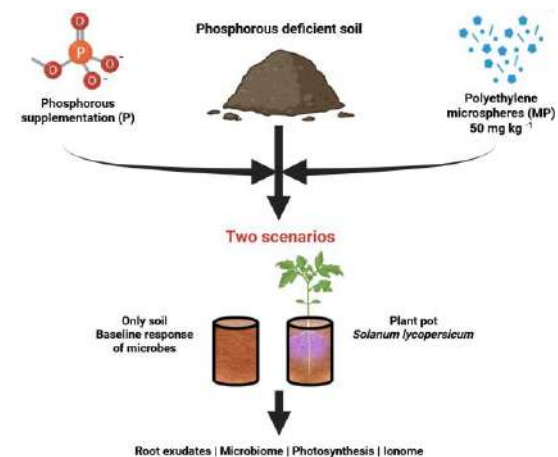


Figure 1. Schematic overview of the experimental design and analyzed rhizosphere processes.



Figure 2. Representative tomato root systems collected during root exudate sampling.

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Plastic pollution in Maldivian mangroves: emerging evidence of macroplastic accumulation

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Keywords: plastic pollution, marine litter, coastal ecosystems, mangrove forests, mangroves management, maldives.

Associated conference sessions: 2

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Mangrove ecosystems are among the most biologically, ecologically, and economically important coastal environments, providing services such as shoreline protection, biodiversity support, carbon sequestration, and fisheries enhancement. Their complex root structures and dense vegetation make them natural traps for marine debris, particularly plastics, with accumulation up to four times higher than on sandy beaches. Nevertheless, mangroves remain understudied in the context of macroplastic pollution, with less than 5% of marine debris research focusing on these habitats.

In the Maldives, a Small Island Developing State, plastic pollution is an escalating concern due to limited waste management capacity. In 2020, an estimated 1.6 kilotons of plastic waste entered the marine environment, largely from landfill leakage, inadequate infrastructure, and maritime activities. Although mangroves occur on 108 islands, no previous study has documented plastic accumulation in these ecosystems.

During three MaRHE Center expeditions in 2024, we surveyed 28 islands across ten atolls and recorded macroplastic debris in four mangrove forests (14% of sites). The most common items, single-use PET bottles, were entangled in stands of *Ceriops tagal*, *Bruguiera cylindrica*, *Rhizophora mucronata*, and *Pemphis acidula* (Figure 1). Accumulations were observed in low-lying, wave-exposed embayments with dense vegetation and shallow depressions, indicating that geomorphology and forest structure drive debris retention. Plastic waste may obstruct roots, hinder seedling development, and compromise ecosystem health.

These findings represent the first evidence of macroplastic pollution in Maldivian mangroves. Given their recent classification as critically endangered by the IUCN, this underscores the need for targeted conservation measures, improved waste management, and integration of mangrove protection into national

marine pollution strategies. As macroplastics degrade into microplastics, future work will assess their presence and distribution in Maldivian mangroves, where no data currently exist.



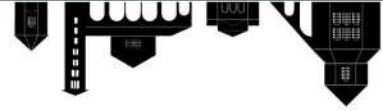
Figure 1. a Map showing the islands where plastic accumulation was documented across the archipelago; b the embayment mangrove of Funadhoo Island; c–f plastic accumulation within the mangrove patch of four Maldivian islands

Session 3 – “Human exposure and adverse health effects of micro and nano plastics: unravelling the mysteries behind these ubiquitous threats”



Oral Presentations





Keynote Speaker: Enrico Bergamaschi - Department of Public Health Sciences and Paediatrics, University of Turin

Title: An integrated approach to assess exposure and early health effects in human populations exposed to micro- and nano-plastics

Abstract:

Although cumulative evidence from in vitro and in vivo studies indicates that micro- and nano-plastics (MNPs) can perturb biological systems, and MNPs have been detected in several human fluids and tissues, the consequences of MNPs exposure to human health still remain unknown. To date, reliable human exposure estimates are hindered by the lack of standardized processing and analytical methods to detect MNPs in complex human biological matrices tissues, and limited evidence on the MNP-related adverse health effects exists. Work environments where plastic materials are produced/handled may represent prioritised settings for evaluating potential health effects on humans because workers experience higher level of exposure - by inhalation - as compared to the general population. To develop effective preventive strategies preventing human exposure to MNPs, it is essential to identify and validate sensitive and specific biomarkers of exposure and early changes in biological systems, which could be precursors to more serious health effects. Biomarkers should ideally be measured in biological matrices collected non-invasively (such as exhaled breath condensate – EBC and urine), or by minimally-invasive procedures (e.g., blood) to enable a periodical health assessment. For a more comprehensive understanding of the potential health risks associated with MNPs exposures, it is recommended using standardized research protocols which integrate exposure monitoring with human biomonitoring to harmonize the methodological approach across studies (Catalán et al, 2025). Future occupational studies aimed at addressing the causal relationship between MNPs exposure and health effects should basically follow the stepwise approach described in the OECD guidance document (Hopf et al, 2024) (Figure 1). Despite the progress achieved, several challenges should still be overcome in future studies. These include the need of working with international multicenter prospective cohorts, whose members

should be deeply involved in the design and execution of the study, allowing proper sample sizes and the assessment of causal relationships. Furthermore, classical validated biomarkers of (early) health effects should be complemented with more specific biomarkers of MNPs' effects, which still need high-throughput methods and further standardization efforts. This work was supported by European Union's Horizon 2020 research and innovation programme under grant agreement No. 965367 (PlasticsFatE).

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Figure 1. The main stages of a human biomonitoring study involving the MNPs assessment.



Invited Speaker: Paolo Bigini - Istituto di Ricerche Farmacologiche Mario Negri (IRCCS)

Invited Speaker: Luisa Diomede - Istituto di Ricerche Farmacologiche Mario Negri (IRCCS)

Title: Development and standardization of a platform to evaluate the biological interaction and safety of micro-nanoplastics

Abstract:

Advanced nanomaterials (Ad-NMs), including micro- and nanoplastics (MNPs), are driving a new industrial revolution, with a global market projected to reach over 33 billion € by 2030. Despite this ongoing development, the actual sight of potential hazards could pose a barrier to innovation in key sectors. To move from perception to quantifying the impact of both Ad-NMs and MNPs, the Center of Preclinical Toxicology and Biochemistry has developed and validated a suite of reliable methods mainly focused on the bio-nano interaction across biological matrices at increasing levels of complexity. The philosophy is to apply and, if needed, integrate well-consolidated approaches developed over the last 60 years in the field of pharmaco-toxicology to the assessment of a broad range of industrial materials and environmentally dispersed end products, including MNPs. The main tools and skills, and a hypothetical workflow for the approach, are shown in Figure 1.

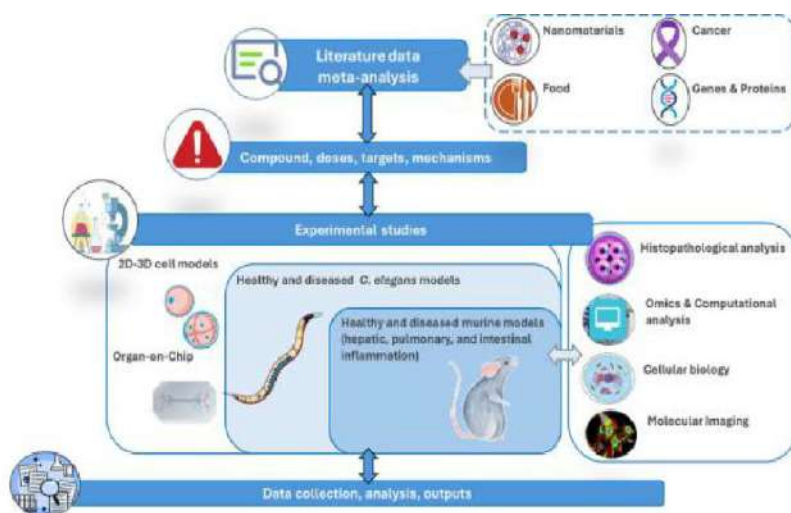


Figure 1. A platform for assessing bio-nano interactions developed by the Center of Preclinical Toxicology and Biochemistry at the Istituto Mario Negri.



In particular, within the POTENTIAL European project, we are developing a safety assessment platform to standardize an innovative, harmonized framework of experimental New Approach Methodologies that will be validated in in vivo studies. In addition, grouping and read-across approaches that meet regulatory risk-assessment requirements will be used to quantify risk thresholds. These methods will be integrated into a Methodological Framework for quantitative ranking of health and environmental hazards to support Safe-and-Sustainable-by-Design of Ad-NMs in line with the goals of the European Green Deal and the Chemical Strategy for Sustainability.

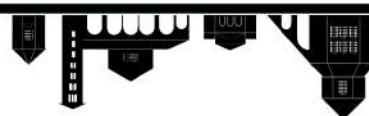
The different in vitro and in vivo approaches used to assess the risk of selected MNPs and to serve as a reference for optimizing the platform will be described. We will also introduce paradigmatic examples of how the physicochemical properties of MNPs, such as the nature of the plastic material, size, and surface charge, can significantly impact interactions with the biological target and data interpretation.

This extremely important concept further reinforces the need to carry out such risk assessments using quantitative criteria and complementary procedures and models.

This work was supported by the European Union's Horizon Europe RESEARCH AND INNOVATION ACTIONS PROGRAMME, Project "Platform Optimisation to Enable Nanomaterial Safety Assessment for Rapid commercialization (POTENTIAL)", Grant number 101092901. This study was conducted under the Italian Institute for Planetary Health (IIPH) framework.

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Microplastics interacts with the Intestinal Epithelial Barrier and disrupts permeability

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Microplastics (MPs) represent a significant, persistent, widespread and largely uncontrolled threat to human health. MPs have pervasively entered the food chain and have already been detected in numerous biological samples, both in marine animals and in humans, where ingestion seems to be the main route of exposure (Zantis et al., 2021; Senathirajah et al. 2021).

Once ingested, MPs can act as vectors for environmental pollutants, but also exerting intrinsic toxicity due to the presence of their polymers and the industrial chemical additives contained (Rochman et al. 2013).

Several studies have shown that exposure to MPs can lead to alterations in the gut microbiota (GM) and the intestinal endothelial barrier (IEB), promoting chronic inflammation, leaky gut syndrome, and the uncontrolled translocation of pathobionts, toxins, xenobiotics, and MPs themselves into the bloodstream (Nissen et al., 2024, Jia et al., 2023). Studies in mice and in vitro suggest that the negative effects of MPs on IEB could be mediated by alterations in the GM (Nissen et al., 2024, Jia et al., 2023), but there is also evidence of a direct effect of MPs on the intestinal epithelium, with mechanisms not yet fully elucidated. To investigate the effects of MPs on intestinal epithelial integrity, NCM460 cells were grown as confluent cell islands and then exposed to polystyrene MPs of three different sizes (2, 10 and 45 μm) for 24 hours. Elucidating these processes may be essential for understanding MPs adverse effects on humans.

To assess the functional impact of MPs on barrier integrity, we carried out analyses based on the measurement of transepithelial electrical resistance (TEER), on optical (confocal) and scanning electron microscopy (SEM) and on the evaluation of the gene expression of cell junctions' proteins (tight and adherens junction) by real-time PCR.

TEER measurements on colonocyte monolayers revealed that MPs exposure caused a modest, concentration-dependent reduction, suggesting that high MPs loads (regardless of particle size) may directly affect barrier function. Confocal microscopy revealed actin cytoskeleton reshaping around MP particles,

suggesting an active interaction regardless of particle size. SEM analysis confirmed this hypothesis, showing that 2 μm MPs entered the cell, while larger particles (10 μm) appeared to engage the cell surface.

Gene expression analysis confirmed that MPs exposure significantly affect the transcription of key intestinal permeability-related genes, including tight junction components (CLDN1, CLDN2, CLDN15, OCLN, TJP1, TJP2, F11R), adherens junction markers (CDH1), and the cytoskeletal regulator MYLK. In this case, the most pronounced effects were observed for the smallest particle size (2 μm), consistent with their higher cellular uptake and interaction efficiency.

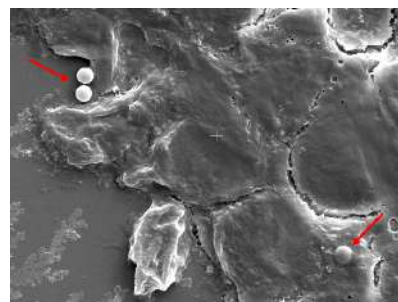


Figure 1. A 2 μm sized particle engulfed in a NCM460 cell cluster and two 2 μm MPs still on the surface.

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A multicellular 3D-airway assembloid model to assess the impact of micro- and nanoplastics on the human lung health: “life in plastic is not that fantastic”

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Keywords: assembloids, airway, lung, organoid, micro-nanoplastics.

Associated conference sessions: 3. Presenting author email: mariachiara.iachini@policlinico.mi.it

The steady increase in global plastic production has led to a massive accumulation of waste that degrades into micro- and nanoplastics (MNPs). These particles are now ubiquitous in the atmosphere, reaching even the remotest areas of the planet. While found from the Arctic to the deep oceans, the closest exposure occurs right here, in our lungs. Recent evidence identifies inhalation as the primary route of human exposure, with estimates suggesting that individuals may inhale up to 150,000 particles annually, posing a significant and direct threat to respiratory health (Ernhofer B, 2025).

However, current risk assessments rely on oversimplified 2D cultures, lacking structural complexity, or on animal models, limited by inter-species differences. These constraints fail to capture essential human physiological responses, such as muco-ciliary clearance and cellular cross-talk, creating a gap in our toxicological understanding. In the absence of a physiologically relevant platform, researchers often recur to extreme shock doses to elicit measurable acute effects. To address this, we developed a human 3D airway assembloid model, a high-fidelity New Approach Methodology (NAMs) integrating epithelial, stromal and endothelial components for a more accurate and human-relevant MNPs risk assessment. The model was generated from healthy lung tissue donors (CE-0006851) by using a scaffold-free culture system to promote cell self-organization (Iachini MC, 2025). Assembloids exhibited long-term viability, maintained typical airway epithelial markers and demonstrated functional characteristics, such as mucus production and ciliary beating.

Bridging the gap between traditional organoid cultures and complex tissue engineering strategies, this technology provides a powerful platform for investigating the impact of MNPs under environmentally relevant conditions, aiming to uncover

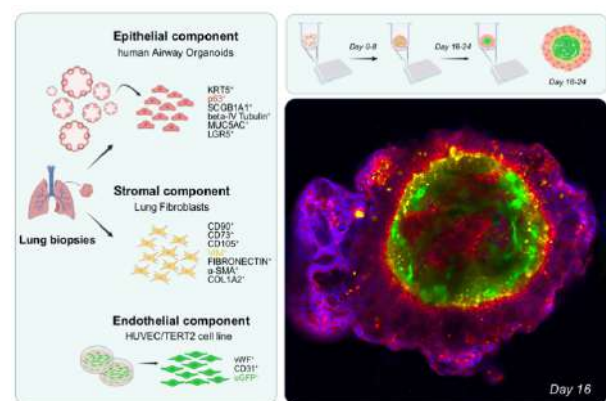


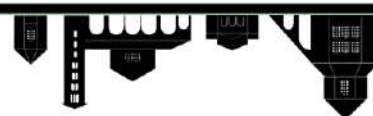
Figure 1. Schematic representation of seeding protocol of the model (top and left). Representative confocal image of human airway assembloid at day 16 (right). Basal cells represented by p63 (in red), lung fibroblast by vimentin (in yellow) and HUVEC/TERT2 eGFP+ (in green). Journal cover (Iachini MC, 2025).

biological responses that remain poorly characterized in current literature. To date, the model is used to elucidate the inflammatory and oxidative stress pathways triggered by 50nm nanoplastics within this human architecture. Therefore, by simulating the evasion of natural barriers, it is possible with the platform to clarify the pathological fate of these ubiquitous aerosols within the deep lung.

This work was supported by Next Generation EU-NRRP M6C2, Enhancement & Strengthening of Biomedical Research in the NHS PNRR-POC-2022-12375642 and by Ricerca Corrente - Italian Ministry of Health.

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Aged polystyrene leachates affect Human Dental Pulp Stem Cells

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Keywords: Nanotoxicology; Polystyrene; Aged plastic; Mesenchymal Stem Cells.

Associated conference sessions: 3

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Polystyrene is one of the most commonly used plastic polymers and a major component of plastic debris widely released into ecosystems¹. Its impact on aquatic habitats is well-documented, nevertheless, little is known about the effects of microplastics and nanoplastics on terrestrial species, and, due to lack of evidence, the results of their toxicity at the cellular level are still controversial.

Therefore, we investigated the effects of pristine and aged polystyrene micro- and nanoplastics on human dental pulp stem cells, a subpopulation of mesenchymal stem cells embedded within the pulp cavity of teeth. Our results showed that, although particles of both sizes were internalized by the cells, primarily through endocytosis, they did not affect cell viability. However, they induced cytoskeletal disorganization, leading to reduced actomyosin cortex integrity (Figure 1).

In contrast, leachates derived from the particles significantly reduced cell viability and activated inflammatory and oxidative stress pathways; however, no significant effects were observed on the expression of genes related to stemness or senescence.

These findings suggest that polystyrene degradation products pose greater toxicological risks to human health than the particles themselves. Based on these results, we have shifted our focus to investigating the effects of pristine plastics and their leachates on those cell lines, such as THP-1 monocytes and THP-1-derived macrophages, involved in the inflammation response.

Furthermore, to elucidate the chemical nature of the leached compounds, future studies will employ advanced analytical chemistry techniques. Integrating chemical profiling with biological assays will provide a

more comprehensive understanding of the potential risks that micro- and nanoplastics pose to human health.

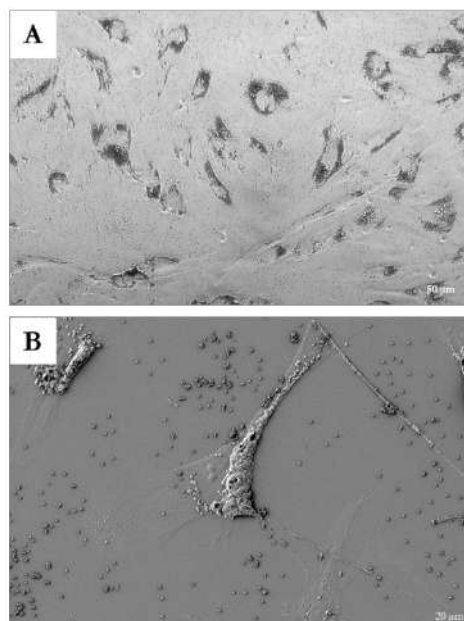
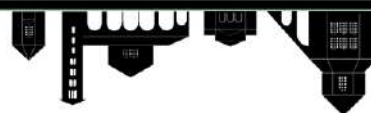


Figure 1: Optical microscopy (A) and SEM (B) images of DPSCs exposed to PS particles, clearly showing the particles massively accumulated in the cytoplasm.

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Mechanical grinding of polypropylene bottles during pilot-scale recycling generates micro- and nanoplastic particles that can induce pro-inflammatory responses in macrophages

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Keywords: micro and nanoplastics, polypropylene, human exposure, adverse health effects, macrophages.

Associated conference sessions: 3

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Mechanical processing of plastic generates airborne micro- and nanoplastic particles (MNPs), raising concerns about occupational inhalation exposure. Polypropylene (PP) is among the most widely produced polymers globally and is extensively used in consumer packaging, including beverage and food bottles. However, biological impact of MNPs generated during PP recycling remains poorly characterized.

This study investigates the physicochemical properties and pro-inflammatory effects of MNPs produced by mechanical grinding of PP bottles using an *in vitro* macrophage model. MNPs were generated from PP bottles using a grinding system designed to simulate mechanical recycling processes. Two categories of materials were investigated: commercial unused PP bottles (PPc) and post-consumer PP waste bottles (PPw). The latter were recovered through an industrial partner (Polyvia). Generated particles were recovered and prepared as suspensions in bovine serum albumin (BSA) for physicochemical characterization (μ -Raman spectroscopy and scanning electron microscopy) and *in vitro* toxicological assessment.

Biological effects were evaluated using RAW 264.7 murine macrophages. Cells were exposed to MNP suspensions at concentrations ranging from 15 to 120 $\mu\text{g}\cdot\text{mL}^{-1}$ for 24 hours. Cytotoxicity was assessed through a lactate dehydrogenase (LDH) release assay, while proinflammatory responses were evaluated by quantifying the secretion of Tumour Necrosis Factor- α (TNF- α) using an ELISA assay.

Results showed that exposure to MNPs derived from PP-based bottles did not induce detectable cytotoxicity. In contrast, macrophage activation was observed through the induction of TNF- α secretion following exposure to particles derived both from PPc and PPw. These results indicate that mechanically generated PP particles can stimulate pro-inflammatory signalling in macrophages even in the absence of overt membrane damage. Similar inflammatory responses to microplastics have been reported in macrophage models exposed to polymer particles, highlighting the

ability of small plastic fragments to activate immune pathways (Hwang *et al* (2019); Goodman *et al* (2021)).

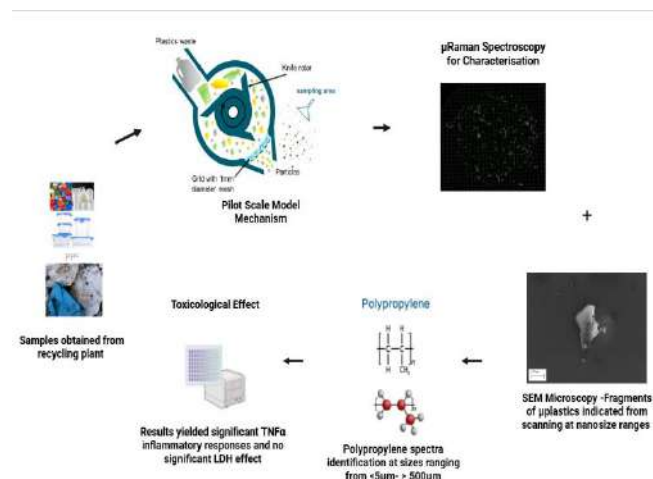


Figure 1: Schematic overview of understanding microplastic exposure from plastic recycling, and its toxicological impact.

Overall, these findings demonstrate that MNPs generated during the mechanical grinding of PP bottles may induce proinflammatory responses in macrophage cells. Given that grinding and shredding processes are common in plastic recycling facilities, these results highlight the importance of considering airborne microplastic exposure in occupational environments, where workers may be repeatedly exposed to inhalable plastic particles from the mechanical processes.

This work was supported by the Petroleum Tertiary Development Fund (PTDF), Nigeria and Agence De l'Environnement et de la Maitrise de L'Energie (ADEME), France.

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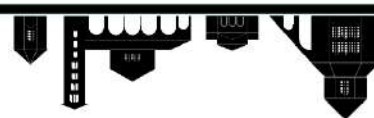
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Session 3 – “Human exposure and adverse health effects of micro and nano plastics: unravelling the mysteries behind these ubiquitous threats”



Poster





Impacts of Micro and Nano Plastics on Brain and Intestine Inflammation Through [¹⁸F] FDG PET/CT Imaging and Immunohistochemistry

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Associated conference sessions: 3

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Keywords: Plastics, Brain, Intestine, Inflammation, Neurotoxicity

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Environmental dispersion of microplastic (MPs) and nanoplastic (NPs) debris is becoming a prominent concern for human health (Aschner M, 2025). In the last century we have been facing a massive usage and constant exposure to plastics in the daily life; moreover, their improper disposal leads to their partial decomposition/fragmentation by physical/chemical factors and accumulation in the environment. From here, MPs and NPs are absorbed by the human body through respiration with other air pollutants, as well as by ingestion through the food chain, due to the widespread presence of MPs and NPs in the water and all food products (Paul et al., 2020). Our previous study (Bonanomi et al., 2022) demonstrated that the internalization of plastic particles by human colon cells can alter cellular metabolism and promote the acquisition of a tumor-like phenotype.

Based on their ability to cross biological barriers and to induce toxicity (Baroni et al., 2025), our study aimed to assess whether MPs and NPs exposure is accompanied by an inflammatory response in brain and intestine. To this end, groups of mice were exposed to MPs or NPs by oral gavage or treated with AOM/DSS or vehicle as positive and negative control, respectively, and analyzed by [¹⁸F] FDG PET/CT imaging in combination with immunohistochemistry. We evaluated microglial and astrocytic markers by assessing GFAP and Iba1 expression and their distribution in the brain and intestine, together with

[¹⁸F] FDG brain uptake

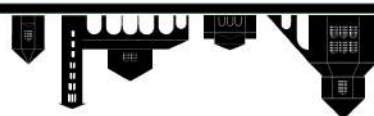
Mice treated with MPs and NPs exhibited significantly different [¹⁸F] FDG uptake in total brain compared to vehicle and AOM/DSS exposed mice, respectively, together with a region-specific increase in uptake in selected brain areas, including the hippocampus.

In addition, IHC data on brain and intestine revealed that exposure to MPs causes an inflammatory response similar to that of the positive control AOM, as indicated by the significant increase in GFAP and Iba1 levels, compared to vehicle mice; whereas no relevant activation is observed in NPs-treated mice. The different behavior of MPs and NPs reproduces what is observed on primary astrocytic culture in terms of mechanism of internalization and neurotoxicity.

This work was supported by Department of Medicine and Surgery, University of Milano Bicocca, Milan, Italy; Department of Nuclear Medicine, San Raffaele Scientific Institute, Milan; CNR, IBSBC, Segrate, Milan; and Laboratory of Neuroscience "Rita Levi-Montalcini" Dept of Biotechnology and Biosciences, University of Milano Bicocca UNIMIB, Milan, Italy.

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Nanoscale membrane disruptions induced by polymeric nanoplastics in human umbilical vein endothelial cells (HUVECs) revealed by synchrotron nano-XRF imaging

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Keywords: nanoplastics, developmental health, HUVECs, nXRF, structural alterations.

Associated conference sessions: 3

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Micro- and nanoplastics are emerging environmental contaminants with increasing evidence of human exposure, including during sensitive developmental stages (Ragusa, 2021). However, their interactions with cellular structures and their impact on membrane integrity remain poorly understood, largely due to limitations in detecting and validating nanoplastics at the nanoscale within biological systems.

In this study, we investigated the interaction of polymeric nanoplastics with human umbilical vein endothelial cells (HUVECs) using a multimodal approach combining flow cytometry, confocal microscopy, and synchrotron-based nano X-ray fluorescence (nXRF) imaging. Polypropylene (PP) and polyvinyl chloride (PVC) nanoplastics labelled with CdSe quantum dots were used as model systems for correlative detection.

Synchrotron nXRF imaging at 100 nm spatial resolution enabled the direct visualization of nanoplastic-associated elemental signals (Pascolo, 2023) within cells and revealed nanoscale alterations at the cellular borders. Sulfur-associated signals, used as a proxy for protein- and membrane-rich regions, displayed localized vacuole-like discontinuities along the cell periphery in exposed cells. Quantitative analysis demonstrated a significant increase in the frequency of these discontinuities, especially in PP-treated cells.

These structural alterations were confirmed by flow cytometry, showing increased phosphatidylserine externalization and membrane permeability, as indicated by Annexin V and propidium iodide staining. Notably, PP nanoplastics induced stronger membrane permeability, whereas PVC nanoplastics showed a more confined intracellular distribution and promoted enhanced small vesicular responses.

This work provides direct nanoscale evidence linking nanoplastic localization to membrane alterations and functional impairment in endothelial cells. The integration of synchrotron-based elemental imaging with functional assays represents a powerful strategy to investigate nanoplastic–cell interactions, providing a more accurate assessment of their potential impact on fertility and newborn health.

This work was supported by the Italian Ministry of Health, through the contribution given to the Institute for Maternal and Child Health IRCCS Burlo Garofolo, Trieste - Italy (RC 38/23).

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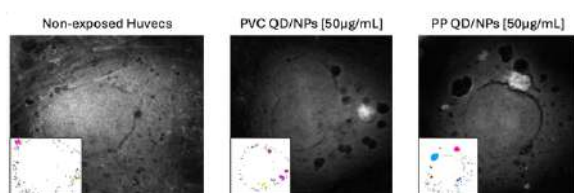
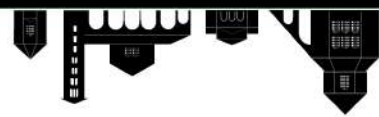


Figure 1. Representative sulfur (S) nano-XRF maps of control HUVECs and cells exposed to PVC or PPQDs/NPs (50 µg/mL), with segmented insets employed for the quantification of discontinuities.



Development of a dynamic 3D *in vitro* model of the neurovascular unit to investigate micro/nano-plastics neurotoxicity

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Keywords: Micro/nano-plastics, neurovascular unit, neurotoxicity, 3D model, microfluidic device

Associated conference sessions: Human exposure and adverse health effects of micro and nanoplastics: unravelling the mysteries behind these ubiquitous threats

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Micro/nano-plastics (MPs/NPs) are ubiquitously found in various environments and uptake occurs through multiple routes including ingestion, dermal contact and inhalation. Recent experimental and clinical data suggest that brain accumulation and neurotoxicity of MPs/NPs may contribute to the onset of different neurodevelopmental and neurodegenerative conditions (Liua Shuang, 2024; Wang Genghuan, 2024). Although the mechanisms underlying MPs/NPs-induced brain damage are not yet understood, these particles may alter the function of the neurovascular unit (NVU), whose impairment is involved in many diseases such as Alzheimer's (Sweeney Melanie D., 2018).

The aim of this work is to investigate the effect of polystyrene, a largely airborne diffused plastic material, on the NVU by initially using a well known culture model for human blood-brain barrier, represented by brain microvascular endothelial cell line hCMEC/D3. However, traditional bidimensional models still present some limitations, such as the inability to reproduce the structural complexity of biological systems. Therefore, our next approach to address these issues is to build a tridimensional (3D) *in vitro* model of the NVU. This innovative platform finds multiple applications such as disease modelling and it is essential to obtain translationally relevant results and align with the 3R policies.

We first exposed hCMEC/D3 to fluorescently labeled polystyrene nanoparticles, analyzed the localization and eventual internalization of the particles through immunofluorescence microscopy and evaluated their effect on the functional activity of hCMEC/D3 with the calcium imaging technique. The next step in our research is to transition to a 3D *in vitro* model of the NVU, which is better suited to replicate

the dynamicity of the physiological condition. This model is composed by the different cells of the NVU differentiated from human induced pluripotent stem cells, increasing its translational potential. The cells are integrated in a microfluidic device mimicking the presence of a blood flow, which is both efficient to reproduce the shear stress suffered by cells and to perform MPs/NPs exposure. After an initial characterization of the model, the response of NVU cellular components to polystyrene exposure will be evaluated with multiple methods, including immunocytochemistry, protein expression analysis and electrophysiological techniques.

Future research will focus on applying this approach to multiorgan studies to investigate how MPs/NPs can possibly distribute in different interconnected systems. This work may contribute to study the functional mechanisms of pollution-induced neurotoxicity and to possibly influence the development of more sustainable environmental policies.

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Hazard assessment of advanced nanotextiles in a safe and sustainable by design perspective

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Keywords: nanocoated textiles, skin irritation, safe and sustainable by design

Associated conference sessions: 3,4

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Advanced textiles are gaining attention due to their enhanced features. Moreover, the incorporation in polymeric textiles (i.e. polyester) of eco-friendly nanoparticles (NPs), such as silver NPs functionalized with hydroxyethylcellulose (AgHEC) or curcumin (AgCUR), paves the way to the development of safe and sustainable antimicrobial nano-textile. However, the hazard assessment of these materials is made even more complex due to the possible release of polymeric fibres and microplastics (MNPs) from the fabrics during their use-phase. In this work, the irritant potential of polyester fabrics coated with AgHEC and AngCUR NPs was evaluated by using a reconstructed *in vitro* model of the human epidermis (RhE, EpiDerm™), by simulating the use-phase for the human exposure, following the safe and sustainable by design (SSbD) principle (Caldeira et al. 2022). The extraction of textiles was performed by incubating the fabrics in artificial sweat (AS) at physiological pH (4.7) for 72h at 37°C under continuous shaking (ISO/TC 194/WG 8). Blank uncoated textiles were included as reference control. Moreover, the irritative potential of polyester fabrics spray coated with AgHEC NPs under different conditions (i.e. different final concentrations of NPs, spraying speed, flow rate etc.) was also assessed following a SSbD perspective. The irritative potential was performed following the skin irritation test (OECD 439). Skin tissue viability and the release of pro-inflammatory mediators (IL-8) were investigated after 18h of exposure to fabric extracts (Fig. 1). The leachates were characterized by GC-MS after extraction of the liquid phase using Direct Immersion Solid Phase Microextraction (DI-SPME), liquid-liquid microextraction (LLME), and TEM/SEM analyses. After 18h of exposure to leachates none of the tested samples resulted to be irritant on the skin model (tissue viability >50%). However, results showed that leachates

derived from the textiles w/o coating (Blank), induced a slight but significant reduction of cell viability, as well as increased release of IL-8 in the basal compartments of skin tissues, suggesting that the handling of textiles and the possible release of fibres from fabrics could be responsible of the inflammatory effect observed.

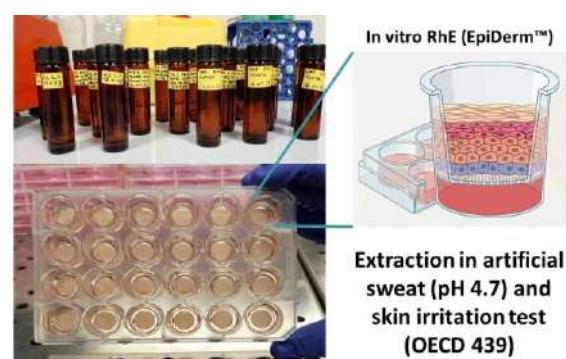


Fig. 1- Representation of the experimental design.

These observations highlight that during the hazard assessment of advanced materials the possible release of substances of concern (e.g. MNPs, phthalates) from the textiles, could influence the inflammatory potential. Moreover, alternative designing strategies such as different type of nanoparticles or of spray coating parameter could help in reducing the irritative potential of nanocoated textiles.

This work was supported by European Union's Horizon Europe research and innovation programme under GA No 101138414, INTEGRANO project

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Human Exposure to Micro and Nano- plastics and Risk Assessment

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Keywords: Biological Barriers; Human Exposure; Microplastics; Nanoplastics; Risk Assessment

Associated conference sessions: 3

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Today's world have encountered Microplastics and Nanoplastics (MNP) as a prevalent environmental pollutant with an evident human exposure via inhalation, ingestion and to a lesser extent via dermal contact. Due to their small size, persistence, varied physicochemical properties these particle facilitate interaction with crucial biological barriers like pulmonary barriers, placenta, blood brain barrier and gastrointestinal epithelium.

Recent laboratory, animal, and human biomonitoring studies indicate that MNPs can migrate beyond primary entry sites into systemic circulation, potentially accumulating in secondary organs including the liver, reproductive tissues, and brain. This translocation is linked to oxidative stress, inflammatory conditions, immune dysregulation, endocrine disruption, and potential carcinogenic pathways.

New evidence of MNPs being found in human placentas, blood, lung tissue, and cardiovascular plaques has strengthened the understanding of health effects that last a lifetime or even across generations. However, realistic exposure assessment continues to be difficult because of problems with methods, contamination risks, and a lack of standardized detection protocols. Organ-on-chip systems, sophisticated human barrier models, and high-throughput toxicology platforms are examples of New Approach Methodologies (NAMs) that are increasingly useful for minimizing animal use while enhancing mechanistic understanding of MNP toxicity in accordance with 3R principles.

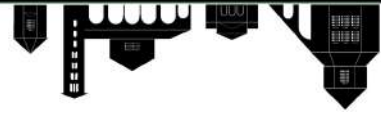
The present study focuses on synthesizing present understanding of human exposure pathways, barrier penetration systems, organ-specific adverse effect and innovative risk assessment strategies. Developing evidence-based regulatory frameworks and preventive measures to lessen these ubiquitous risks to human health requires an understanding of how MNPs breach biological defences.

Acknowledgments

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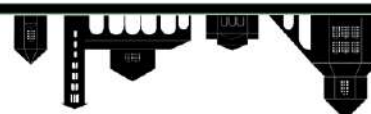
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Immune responses of human monocytes to pristine and UV-aged micro- and nanoplastics

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Keywords: microplastics, nanoplastics, monocytes, inflammation, photoaging

Associated conference sessions: 3

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The widespread presence of micro- and nanoplastics (MNPs) in the environment has raised increasing concerns regarding their potential impact on human health. Chronic exposure to MNPs has been linked to inflammatory responses and immune system impairment (Campanale et al., 2020; Prata et al., 2020; Wright and Kelly, 2017), increasing the risk of chronic and autoimmune diseases (Deng et al., 2017). Although MNPs have been shown to affect immune cell function, the mechanisms underlying their effects, particularly after environmental aging, remain poorly understood (Lambert and Wagner, 2016).

This study investigates the *in vitro* effects of pristine and UV-aged MNPs on primary human monocytes, focusing on inflammatory responses and immune-related pathways. Monocytes were exposed to MNPs of different sizes and concentrations, and cellular responses were assessed by flow cytometry and gene expression analysis (qPCR), targeting pathways involved in inflammation and antigen presentation.

MNP exposure induced significant size-dependent immunomodulatory effects. Pro-inflammatory responses were markedly increased, with elevated expression of IL-1 β , IL-8, and TNF α , particularly at larger particle sizes. NF- κ B was also upregulated, supporting enhanced inflammatory activation.

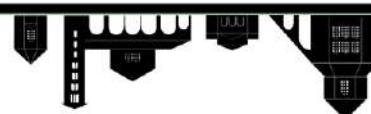
In parallel, HLA-A expression was reduced, suggesting a potential impairment of antigen presentation. Conversely, downregulation of NLRP3 indicates a modulation of inflammasome-related pathways, pointing to a possible decoupling between inflammatory signaling and inflammasome activation.

Notably, UV-aged MNPs elicited stronger inflammatory responses compared to pristine particles, highlighting the role of photoaging in enhancing MNP immunotoxicity.

Overall, these findings demonstrate that MNPs significantly affect innate immune responses and that environmental aging represents a critical factor in modulating their biological impact.

This work was supported by the Italian Ministry of University and Research (MUR) through the PRIN project (Prot. 2022YMHS18) and benefited from the CRC NEMESIS network coordinated by Prof. Claudio Fenizia.

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ASSESSING THE INTERACTION BETWEEN MICRO- AND NANOPLASTICS (MNPs) AND HUMAN GUT MICROBIOTA

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Keywords: Microplastics, Gut Microbiota, Biodegradation, Dysbiosis, Human Health.

Associated conference sessions: 3

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Abstract:

Introduction: Micro- and nanoplastics (MNPs) are pervasive environmental pollutants, with the human food chain serving as a primary route for ingestion. The gastrointestinal tract is the first point of accumulation, yet the complex interaction between MNPs and the resident microbiota is not fully understood. This study investigates this relationship: the potential for MNPs to induce gut dysbiosis and the capacity for intestinal bacteria to utilize plastic substrates for metabolic activity.

Methodology: Representative polyethylene terephthalate (PET) MNPs (produced via chemical catalysis) and polypropylene (PP) MNPs (produced via UV-degradation) were utilized. Gut transit was simulated by incubating fecal samples for 48 hours at 37°C under anaerobic conditions with three MNP concentrations (0.1, 1, and 10 mg/mL). Microbial community dynamics were analyzed using 16S rRNA gene profiling and shotgun metagenomic sequencing. Further validation will be performed via qPCR analysis across 20 independent fecal samples.

Results: A significant reduction in bacterial alpha-diversity was observed at the highest concentrations (10 mg/mL) of both PET and PP: fewer bacterial species mean less resilience and functionality in the community. This shift favored specific taxa characterized by hydrocarbon and ester cleavage activities. Shotgun sequencing identified an enrichment of metabolic pathways related to plastic degradation and specific upregulated genes. Among these, *PnbA* was identified as a gene encoding a para-nitrobenzyl esterase, capable of cleaving the ester bond in PET. This gene has been proposed as a biomarker of exposure to plastic in loggerhead turtles and was also detected in human fecal samples, allowing the design of specific primers. Its enrichment will be confirmed via qPCR across multiple human donors, showing a potential enhancement of plastic-degrading bacteria, in response to a community adaptation to persistent MNPs in the human gut.

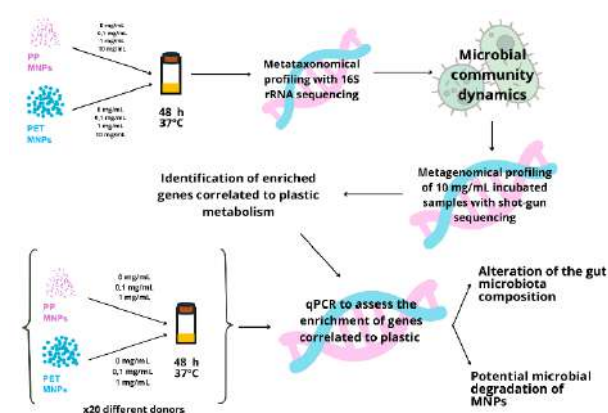
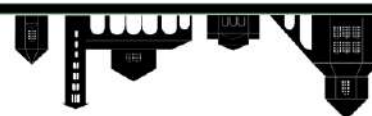


Figure 1. Overview of the workflow and the methodologies employed in the present study

Conclusions & Implications: This study demonstrates that MNPs significantly alter human gut microbial composition and diversity. However, the enrichment of specific microbial consortia suggests an adaptive metabolic response, pointing toward a specialized plastic-degrading potential within the human microbiome. Through the application of a standardized approach with characterized MNPs, this research provides a framework for future risk assessments regarding human exposure and planetary health.

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The surface charge of plastic nanoparticles plays a key role in their interaction with biological matrices

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Keywords: nanoplastics, polystyrene, cells, endocytosis, *C. elegans*

Associated conference sessions: 2,3

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Micro- and nanoplastics (MNPs) can interact with various biological matrices, posing an “eco-toxicology” issue for animal and human health. Despite the great interest, a univocal understanding of the mechanisms driving the toxicity of MNPs remains lacking. Understanding how factors such as the external surface charge affect protein corona formation and influence biodistribution and toxicity is essential for improving sustainable plastics production.

Using polystyrene nanoparticles (PS-NPs) as a prototypical material, we investigated the impact of surface charge on biological interactions and toxicity at both the cellular and organismal levels. We employed amine-modified positive and carboxylate-modified negative rhodamine-labeled PS-NPs, which were both spherical, had a diameter of 100 ± 30 nm, were monodispersed, and differed only in z-potential (+51 mV and -9 mV), to avoid potential bias.

Human embryonic kidney (HEK) 293 cells, widely employed for nanotoxicological studies, were used as models because of the kidneys' role in NP excretion. In addition, the nematode *Caenorhabditis elegans*, widely used in nanotoxicity studies, was employed as an in vivo animal model. This nematode is ubiquitous worldwide, living in the water and soil of arctic, subarctic, and temperate regions, making it also an excellent environmental indicator.

The internalization pathway was investigated using pharmacological inhibitors of endocytosis (chlorpromazine and amiloride) and intracellular vesicle labeling. NPs entered cells primarily via clathrin-mediated endocytosis and were rapidly sequestered by lysosomes. Internalization in cells was markedly higher for positive PS-NPs, likely due to electrostatic attraction to the cell membrane, resulting in dose-dependent toxicity in the range from 2.5 to 25 $\mu\text{g}/\text{ml}$.

Because interactions with different biological fluids can play a pivotal role in the cellular uptake of NPs, we investigated the potential roles of serum pre-incubation and protein corona formation. The presence

of serum proteins drastically modified the surface charge of both positive and negative PS-NPs and reduced their cellular internalization.

Finally, the potential in vivo toxicity of PS-NPs was evaluated by administering them to *C. elegans* and assessing their acute and subacute effects, including viability, feeding behavior, neuromuscular function, reproduction, and development. Positive and negative PS-NPs have the same distribution in *C. elegans*, and, as observed in vitro, only positive ones were toxic. They specifically affected worm viability ($\text{IC}_{50} = 11.8 \mu\text{g}/\text{ml}$) and exerted a sub-toxic effect, causing alterations in normal development, impaired feeding behavior, and impaired motility.

These findings underscore the crucial role of the surface charge of PS-NPs in their cellular and animal accumulation and toxicity. In addition, they provide valuable insights into the role that each physicochemical parameter can exert in the potential health risks associated with MNPs pollution.

This work was supported by the European Union's Horizon Europe RESEARCH AND INNOVATION ACTIONS PROGRAMME, Project “Platform Optimisation to Enable Nanomaterial Safety Assessment for Rapid commercialization (POTENTIAL)”, Grant number 101092901. This study was conducted under the Italian Institute for Planetary Health (IIPH) framework.

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Analysis of production and characterization of PLA micro and nanoplastics using ball-milling

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Keywords: PLA, ball-milling, microplastics, nanoplastics, environmentally

Associated conference sessions: 1

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Poly-lactic acid (PLA) is a biodegradable, bio-based thermoplastic derived primarily from renewable resources such as corn starch or sugarcane. It's widely used in packaging, biomedical devices, textiles, and increasingly in 3D printing, owing to its ease of processing, compostability, and relatively low environmental impact (Hasoon *et al*, 2026)

- While it is generally considered non-toxic in its bulk form, the effects of its degradation products, such as low-molecular-weight oligomers and micro/nanoplastics, on aquatic ecosystems are still poorly understood (Habumugisha *et al*, 2024). For this reason, it's important to explore the environmental fate of PLA micro/nanoplastics. However, even if there is a growing interest in the environmental and biological fate of micro/nanoplastics, research on environmentally relevant samples remains limited. This is mainly due to the difficulties of sampling sufficient amounts of micro/nanoplastics from the environment or of producing representative nanoplastics in laboratories. These limitations are critical specifically for emerging polymers in the technological field such as PLA, for which the formation of environmentally relevant samples is still poorly studied.
- This work aims to address these gaps, by focusing on the PLA micro/nanoplastics production using vibromilling processes (fig. 1) in a liquid environment.

- The results demonstrate the reliability of this approach, due to both the enhanced production yields, and the limited chemical alteration during particle formation.

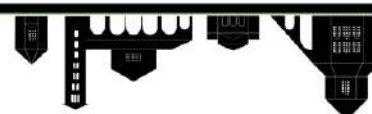


Figure 1: vibro-mill MM500

- The first part will illustrate the reproducibility of PLA MPs protocol through the ball-milling process, while for the NPs, preliminary results will be presented. Ongoing studies are focused on the study of the biological fate of these particles through toxicological exposure experiments.

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The impact of polystyrene nanoplastics on microglial function: Preliminary evidence of neurotoxicity, oxidative stress and impaired neurotransmission

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Keywords: nano plastics, microglia, oxidative stress, inflammation, rehabilitation.

Associated conference sessions: 2,3

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Nano- and microplastics (NMPs) have emerged as ubiquitous environmental neurotoxicants due to their unique ability to pass over selective biological barriers, including blood-brain barrier. Once lodged within brain tissue, these particles disturb neural homeostasis through converging pathways of oxidative stress, mitochondrial dysfunction, and chronic neuroinflammation, mechanisms closely aligned with the molecular signatures of neurodegenerative disorders and brain aging (Nihart et al., 2025; Moulton et al, 2026). Despite the growing body of evidence, the size- and concentration-specific molecular mechanisms by which NMPs impair glial support and synaptic communication remain insufficiently characterized, especially at physiologically relevant concentrations (Baroni et al., 2025).

In this study, we evaluated the impact of 25 nm and 100 nm polystyrene nanoplastics (PS-NPs) on the cellular health and function of BV2 microglial cells. Cells were exposed to physiologically relevant concentrations (1.6, 4.8 and 10 µg/mL) of PS-NPs for intervals of 2, 24 and 48 hours. Cell viability and survival were quantified using MTT assays and Trypan Blue exclusion. Reactive oxygen species (ROS) and nitric oxide (NO) levels were monitored via electrochemical biosensors, while cytokine modulation (IL-6, IL-10, TNF- α) was assessed by ELISA. Intracellular internalization and mitochondrial localization were visualized using confocal microscopy.

Confocal microscopy confirmed the effective internalization of PS-NPs in BV2 cells, with specific intracellular localization within mitochondrial compartments at 24h. Both 25 nm and 100 nm particles induced a significant, time-dependent reduction in cell viability and survival, with lowest levels observed at 24 hours. Smaller NPs (25 nm) triggered higher levels of oxidative species compared to 100 nm particles.

Regarding the inflammatory response, a significant modulation of IL-6 and IL-10 was observed at 24 hours, particularly for the 25 nm size, whereas TNF- α release showed no significant variation.

These preliminary results demonstrate that PS-NPs exert potent, size-dependent neurotoxicity by inducing oxidative stress and disrupting microglial immune responses and homeostasis. This research emphasizes the urgent need to integrate neurotoxicological paradigms into environmental risk assessments to protect human longevity and public health.

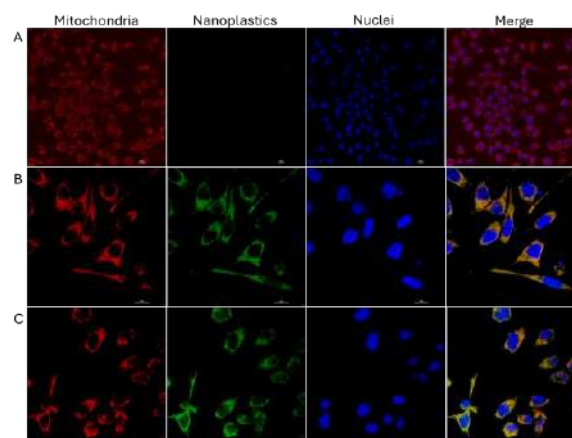


Figure 1. Confocal microscopy of BV2 cells exposed to 25 nm and 100 nm PS-NPs (green) for 24h, showing intracellular localization in relation to mitochondria (red) and nuclei (blue).

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Session 4 – “Promoting Safe and Sustainable by Design, circularity and bioeconomy in polymers innovation”

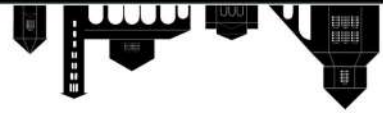


Oral Presentations





Plastics & Environment, 4-5th June 2026, Milan

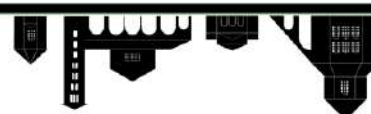


Keynote Speaker: Andrea Amadei - European Commission, Joint Research Centre

Title: Plastic of today and tomorrow: production, consumption, circularity, and innovation at the science to policy interface

Abstract:

Plastic remains a cornerstone of modern industry, yet its linear “take-make-waste” trajectory presents critical environmental challenges. This presentation provides a comprehensive examination of the plastic value chain, transitioning from current production and consumption patterns toward a robust circular economy. Central to this analysis are the results of a first-of-its-kind Material Flow Analysis (MFA) for plastics within the European Union. This MFA granularly quantifies existing stocks and flows from production to end-of-life, providing a transparent baseline at sectors’ and polymers’ levels for evaluating current circularity rates and defining data-driven future scenarios. To evaluate the environmental trade-offs of these transitions, the presentation shares detailed Life Cycle Assessment (LCA) results across various plastic sectors. The research pushes the boundaries of conventional flows accounting by capturing the quantities of microplastic losses in the environment along the value chain, as well as waste mismanagement occurring in the EU. Furthermore, the work explores the shift toward alternative feedstocks, specifically bio-based inputs, and the pivotal role of biotechnologies in transforming waste into high-value secondary raw materials. A key focus is dedicated to the “Safe and Sustainable by Design” (SSbD) framework. The presentation analyzes new approaches for the design of chemicals and materials, including advanced materials, ensuring that functionality does not come at the cost of toxicity or persistence. These technical advancements are contextualized within the evolving legislative landscape. Strategic implications of key policies are mentioned for each aspect, such as the Circular Economy Act, the Bioeconomy Strategy, the Packaging and Packaging Waste Regulation (PPWR), the Advance Materials Act and the Biotech Act II, illustrating how policy frameworks act as catalysts for a sustainable and smarter plastic economy.



DIEGO: A Thermophilic PETase Enabling PET Upcycling for the Circular Bioeconomy

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Keywords: PET hydrolysis, thermophilic enzyme, PETase, enzymatic upcycling, sustainable plastic bioconversion.

Associated conference sessions: 4

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Thermophilic enzymes are biocatalysts naturally adapted to high-temperature environments, where their stability enables activity under conditions that typically inactivate mesophilic counterparts. This robustness has positioned them as promising tools in industrial biocatalysis, and more recently, in environmental field (Bhandari et al., 2021). Enzymatic degradation of plastics is among their most impactful applications, with a particular focus on polyethylene terephthalate (PET), which is one of the most widely used and environmentally persistent plastics.

PET hydrolysing enzymes, also known as PETases and first isolated from mesophilic bacteria, demonstrated the feasibility of enzymatic PET depolymerisation, even though often suffered from low catalytic rates and limited substrate accessibility. Thermophilic PETases address these limitations by operating at temperatures near the glass transition of PET (65 – 85 °C) (Thomsen et al., 2022), where the polymer chains gain mobility and become more susceptible to enzymatic attack. Among novel thermophilic PETases, Depolymerising Isolated Enzyme from Geothermal Origin (DIEGO) proved its ability to hydrolyse PET and its analogues, including bis(2-hydroxyethyl)-TPA (BHET), nanoPET and post-consumer PET. We observed a synergistic effect of DIEGO and temperature at 60 °C: the enzyme converts PET into ethylene glycol (EG), terephthalic acid (TPA), along with the intermediates mono(2-hydroxyethyl)-TPA (MHET) and BHET; while temperature promotes auto-hydrolysis of the intermediates, proving the feasibility of a one-step process for the complete

bioconversion of PET within 4 days (Fig. 1) (Gargano et al., 2025).

The study of thermophilic PETases thus bridges fundamental enzymology with applied biotechnology. By combining high catalytic efficiency with operational robustness, these enzymes represent a sustainable solution for mitigating plastic pollution and a biotechnological platform for circular economy strategies.

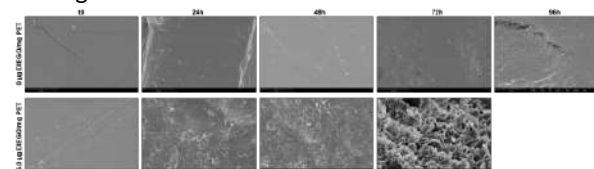
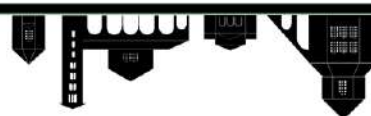


Figure 1. SEM analysis of PET disks incubated with 0 and 5.0 µg of DIEGO/mg of PET, monitored during time

This work was supported by the PRIN project REPLAY grant number 2020SBNHLH_003 and by IBISBA-DIALS project (CUP E26C23000670006).

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An integrated biocatalytic platform for the circular valorization of PET

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Keywords: PET, TPA, *E. coli*, Bioreactor, Amino acids

Associated conference sessions: 4

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The global crisis of microplastic pollution, driven by unsustainable consumption and inadequate disposal, has become one of the most pressing environmental challenges of our time. Among these pollutants, polyethylene terephthalate (PET) is particularly pervasive, posing significant risks to human health (Cui et al., 2023). In our era, the rapid expansion of knowledge and rising awareness offer a substantial opportunity in applied sciences.

In this context, the ProPla (Protein from Plastic) project addresses microplastic pollution by developing a biotechnological approach to convert PET waste into amino acids, with a focus on alanine, a valuable compound for the food and pharmaceutical sectors (Fig. 1).

The process begins with the enzymatic depolymerization of PET using an engineered variant of leaf-branch compost cutinase (Δ LCC) developed to work efficiently at 37 °C (Pirillo et al., 2023). The resulting terephthalic acid (TPA) is funnelled into a complex, twelve-enzyme synthetic metabolic pathway engineered within *Escherichia coli* (Rosini et al., 2025). By successfully implementing a hybrid multi-step platform that integrates whole-cells and recombinant enzymes in tandem, the conversion of TPA to pyruvate via protocatechuate (PCA) and 2-pyrone-4,6-dicarboxylate (PDC), establishing a pioneering platform for the selective synthesis of alanine directly from TPA, was achieved.

To bridge the gap between proof-of-concept and industrial application, we then developed a robust engineering framework focused on genetic stability and flux optimization. The entire pathway was integrated into "safe" genomic loci via CRISPR/Cas9, followed by the implementation of a one-step CRISPRi system

guided by Flux Balance Analysis (FBA) to co-ordinately repress six different targets at the pyruvate node. This optimization led to a two-fold increase in alanine yield during scale-up in a single-step batch bioreactor fermentation.

The framework presented here establishes a scalable blueprint for upcycling PET waste into high-value bio-based chemicals, driving the transition toward a circular bioeconomy. The modular nature of the approach allows its straightforward application to the valorization of other wastes.

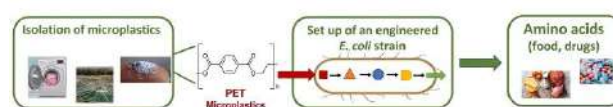
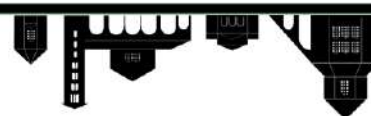


Figure 1. Research approach proposed by the ProPla project (<https://www.theproteinfactory2.it/propla>)

This work was supported by Fondazione Cariplo (Economia Circolare_2022), project ProPla: proteins from plastics, no. 2022-0631.

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PFAS-free biopolymer-based coatings with tailored wettability

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Keywords: polysaccharide, chitosan, textiles, superhydrophobic.

Associated conference sessions: 4

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Polysaccharides are emerging as a versatile platform for the design of sustainable functional coatings. Their polymeric backbone rich in hydroxyl, carboxyl or amino groups provides a high density of chemically addressable sites that enable functionalization and fine tuning of surface properties. Also, their intrinsic ability to form films or micro- and nano-structures makes them particularly attractive for controlling interfacial phenomena. Through suitable chemical modification, polysaccharides can therefore provide a modular strategy to tailor wettability across a wide range of regimes, from highly hydrophobic to strongly hydrophilic surfaces. In this context, polysaccharides represent an attractive alternative platform in the ongoing phase-out of per- and polyfluoroalkyl substances (PFAS), standing out as versatile and sustainable materials thanks to their natural abundance, biodegradability and non-toxicity.

Here we present PFAS-free polysaccharide-based coatings ranging from superhydrophobic to superhydrophilic. Superhydrophobic coatings were obtained by modifying chitosan with stearyl groups through esterification and amidation reactions with stearyl chloride, followed by purification and freeze-drying to obtain a fine powder. The coating was applied to cellulose acetate and polyester substrates using a solvent-free deposition method, yielding high water contact angles due to the combined effect of hydrophobic aliphatic chains and micro-/nano-scale surface roughness, as confirmed by SEM analysis. The durability of the coatings was assessed under acidic aqueous conditions, UV exposure, and mechanical stress. Additional analyses, including TGA-FTIR and biodegradability tests, highlight the environmentally compatible nature of the modified chitosan (Tagliaro et al., 2023, 2024).

Superhydrophilic and hydrophilic polysaccharide coatings were developed to achieve icephobic properties (Marelli et al., 2025). Chitosan and hyaluronic acid were deposited as thin coatings on glass substrates by anchoring them with commercial

adhesion promoters. The combination of smoothness and hydrophilicity resulted in lowering ice adhesion in regimes of ice sliding never reported before, especially in the case of hyaluronic acid.

These results demonstrate the potential of polysaccharide-based coatings as sustainable PFAS-free platforms for controlling surface wettability in advanced applications.



Figure 1. Polysaccharide-based functional coatings: superhydrophobic for textiles (left) and superhydrophilic for glass (right). Illustration generated by ChatGPT.

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Polyhydroxybutyrate-based materials: characterisation and potential applications in agriculture

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Keywords: PHAs, agriculture, chemical depolymerisation, biodegradation, sustainability.

Associated conference sessions: 4

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Conventional plastics are widely used in agriculture, from irrigation components to greenhouse films and mulching sheets, yet their persistence poses growing environmental concerns. Through weathering and mechanical stress, these materials fragment into microplastics that accumulate in soils, where they can persist for decades and interfere with soil structure, nutrient cycling and microbial communities. Despite this, research on microplastic pollution has focused predominantly on marine environments, leaving the impacts on terrestrial ecosystems comparatively understudied Yang *et al.*, (2022). Polyhydroxyalkanoates (PHAs), and particularly poly (3-hydroxybutyrate) (PHB), are a promising alternative to fossil-based polymers. PHAs are the only polyesters naturally synthesised by microorganisms as intracellular carbon reserves, have mechanical properties comparable to those of polypropylene, and completely biodegrade in natural and industrial environments, like industrial composting, fresh and seawater and soil Koller *et al.*, (2025). However, while analytical protocols for quantifying PHB in bacterial cells have been established, comparable methods for non-bacterial or environmentally complex matrices remain largely undeveloped. In this regard, the first objective of this work was to elucidate why PHAs readily biodegrade in soil environments, by integrating microbial analysis, quantification of PHB in soil and degradability tests. Microbiological analyses were performed to evaluate the presence of microbial pools capable of depolymerising and mineralising PHAs. Then, the presence of these pools was confirmed by the application to 12 natural soils of an innovative analytical protocol for the quantification of PHB in

complex matrices. Lastly, six blends of PHB and biodegradable polymers were subjected to degradation and mineralisation tests to exclude the formation of microplastics in the soil. The results of microbial analysis confirmed the presence of ubiquitous soil microorganisms capable of depolymerising and mineralising PHAs, as similarly documented in other ecosystems such as compost, sludge, fresh and saltwater and estuarine sediments (Volova *et al.*, 2017). Natural soils exhibit variable PHB concentrations, ranging from 1 to 200 ppm; this content did not correlate with abiotic soil parameters, suggesting that PHB concentration in pedological environments does not depend on the matrix's chemical-physical parameters, but rather on the specific microfauna present. The degradation rate of the various PHB-based blends depends on their chemical composition, particularly on the specific blending ratio between PHB and the copolymer, suggesting the possibility of fine-tuning the mineralisation rate through the chemical formulation of the products. Fluorescence microscopy analysis of the samples after 32 days of soil exposure highlighted how the material was mineralised by the microorganisms present in the soil.

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Evaluation of biobased carriers derived from agri-food waste for microbial biostimulant delivery in horticulture

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Microbial biostimulants are promising in sustainable agriculture but need to be delivered alive to crops in order to colonise the plant and provide Plant Growth Promotion (PGP) effect. Key challenge is the development of plastic carrier materials that do not rely on fossil resources, while still providing adequate stability, effective field performance, and environmental compatibility (Mapelli *et al.* 2022). This study investigates a circular economy approach to develop bioplastic materials derived from cellulose and pectin for the delivery of two bacterial strains, *Bacillus subtilis* LR01 and *Rhizobium* sp. GR12, which exhibited PGP performance and distinct colonization patterns in the rhizosphere of lettuce and tomato.

When incorporated into two biobased carriers (BC1 and BC2), GR12 did not survive desiccation (Fig.1), and was therefore alternatively encapsulated in alginate beads showing a survival rate of 10^8 CFU/g of material for 28 days of storage. The spore-forming strain LR01 maintained high viability in both BC formulations (10^7 to 10^9 CFU/g) for 28 days. The silica-enriched BC2 formulation was selected for biostimulant delivery in greenhouse trials for its improved structural integrity, while alginate was chosen as benchmark.

Application of both strains as aqueous suspension significantly enhanced lettuce growth increasing leaves biomass by 20% to 30%. Delivery via the selected BC materials maintained bacterial viability and sustained rhizosphere colonization (10^6 to 10^8 CFU/g of soil) but reduced or reversed the PGP effect. Conversely, phenol-related plant secondary metabolism responses were triggered only when bacteria were delivered through the carriers.

Overall, biostimulant performance depended not only on successful alive cell delivery but appeared strongly related with the physiological compatibility with the plant–soil system of the carrier bioplastic.

In conclusion, this study demonstrates that simply being bio-based does not automatically make a material suitable for agricultural applications: it is

essential to assess the physiological compatibility of the bioplastic carrier with the plant–soil system in order to achieve effective and sustainable results.

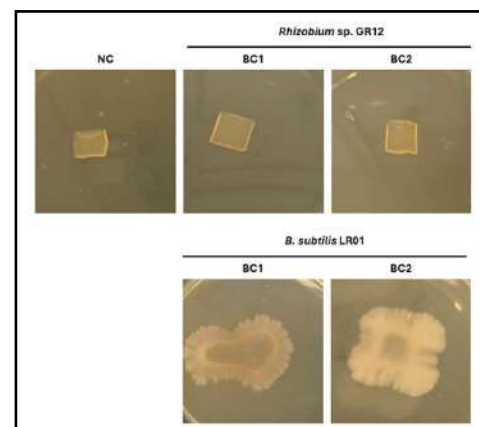


Figure 1. Viability assessment of bacteria incorporated into the biobased carriers: direct placement of BC1 and BC2 films carrying either water (NC, negative control), GR12 and LR01 vegetative cells on TSA medium, showing visible growth only for strain LR01 after 5 days of incubation.

This work was supported by the Cariplo Foundation Project Circular Agri-food Systems: development of biodegradable and biostimulant plant multiplication plugs from fruit and vegetable wastes—BBPlug (Grant No. 2021-0742) and the Agritech National Research Center (European Union Next-Generation EU (Piano Nazionale di Ripresa e Resilienza (PNRR)—Missione 4 Componente 2, Investimento 1.4–D.D. 1032 17/06/2022, CN00000022).

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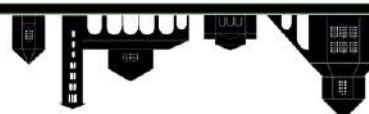
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Session 4 – “Promoting Safe and Sustainable by Design, circularity and bioeconomy in polymers innovation”



Poster





System-level assessment of additives in recyclable polymer value chains using material flow analysis

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Keywords: plastic additives, material flow analysis, circular economy, SSbD, recycling.

Associated conference sessions: 4

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Plastics play a central role across multiple sectors due to their adaptability, cost-effectiveness, and performance. However, despite these benefits, plastics life cycle raises major environmental challenges, particularly at end-of-life, such as limited recyclability and plastic pollution. In this context, achieving a balance between functionality and sustainability requires a deeper understanding of how materials move across plastic value chains.

Material Flow Analysis (MFA) has been increasingly applied to study plastic flows at regional and sectoral levels. Nevertheless, most existing studies focus primarily on the several types of polymers and do not adequately address the complex composition of plastic materials, thus failing to capture the full complexity of plastic materials (Souder, 2024). Plastics are not only composed of polymers, but also include a wide range of chemical substances, such as additives and processing aids, which may be released throughout the entire life cycle and can pose risks to ecosystems, human health, and recycling processes (Wiesinger, 2021). Despite growing attention and regulatory efforts targeting these substances, their behaviour at system level remains poorly understood. In fact, only a limited number of MFA studies explicitly address additives, highlighting a significant gap in the current state of the art.

Within the REDONDO project focused on achieving recyclable polymer systems and bio-based additives, the present study addresses this gap by applying a bottom-up MFA to assess the fate of (bio-based) additives in recyclable crosslinked polyethylene (rPEX) used in water pipe and solar cables applications. The analysis is based on a functional unit of 1 tonne of extruded rPEX pipes/ cables and covers the full life cycle, from additive and product manufacturing to use phase and end-of-life scenarios. Additives are tracked independently from the polymer matrix, allowing their distribution, losses, and retention to be quantified across life-cycle stages. The system is parameterised

using European waste management data and is designed to integrate experimental results from REDONDO, including recyclability and additive retention.

This MFA approach contributes to improving the understanding of how additives move in polymer systems and supports the development of more sustainable and circular materials.

Abstract written thanks to funding from the European Union, within the Horizon Europe programme under grant agreement 101058449.



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Comprehensive Characterization of Novel Ceramic Filler (Black Obsidian) Reinforced Polymer Composites: A Safe and Sustainable by Design (SSbD) Perspective

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Keywords: Black obsidian; ceramic filler; Polymer composites; filler characterization; circular bioeconomy.

Associated conference sessions: 4

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Abstract

The circular bioeconomy demands safe, sustainable polymer composites. This work investigates black obsidian a natural volcanic glass as a ceramic filler in a polymer matrix under the EU SSbD framework. Composites with 5 and 10 wt.% obsidian (9 μm) were prepared by melt mixing and injection moulding. SEM showed good filler dispersion and interfacial adhesion. SSbD screening indicated low hazard and high recyclability. Black obsidian is a promising safe filler for automotive, construction, and consumer goods.

Introduction

Conventional polymer composites rely on synthetic fillers like talc, calcium carbonate, or glass fibres. Although these improve certain properties, their production is energy-intensive, may involve toxic chemicals, and can hinder recycling or biodegradation. Under the European Green Deal and the Safe and Sustainable by Design (SSbD) framework, there is a growing need for natural, inherently safe fillers compatible with circular economy models.

Black obsidian is a natural volcanic glass composed mainly of amorphous silica ($\approx 70\text{--}75\%$ SiO_2) with minor amounts of Al_2O_3 , Fe_2O_3 , and MgO . Its potential as a polymer filler has never been systematically explored. Figure 1 shows a Scanning Electron Microscopy (SEM) micrograph of black obsidian at 1000x magnification. The image reveals the characteristic smooth, amorphous surface morphology of the volcanic glass, accompanied by prominent micro-cracking and a distinct conchoidal fracture pattern (right). Small, irregular particulate debris or secondary phases are also visible scattered across the surface.

This study provides a comprehensive characterization of black obsidian filler including particle size, morphology, composition, thermal stability, and UV absorption and evaluates the material against SSbD criteria (hazard assessment, resource efficiency,

recyclability). The goal is to demonstrate that a naturally sourced, non-synthetic filler can meet performance requirements while contributing to a safer and more circular polymer economy.

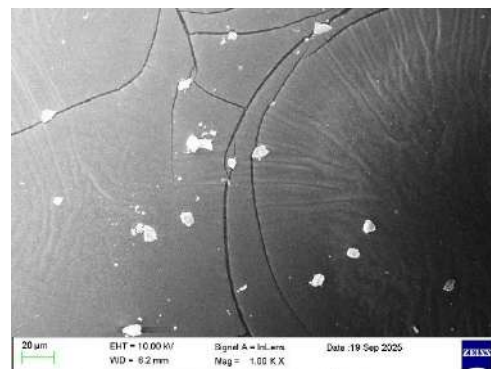
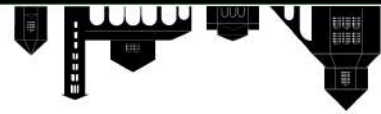


Figure 1. SEM surface morphology of black obsidian (1000x) displaying classic brittle and conchoidal fracturing.

Acknowledgement: The authors sincerely thank the management of Alliance University, India, for providing the necessary research facilities and financial support.

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PLEIADES: Design-Driven Innovation for Sustainable Polymer Products

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Keywords: Ecodesign, Sustainability design, Injection moulding, Product innovation, life cycle assessment

Associated conference sessions: 4

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PLEIADES - Plastic European Innovation Award for Design and Sustainability - is an initiative designed to move beyond the linear “take-make-dispose” model toward a circular economy based on manufacturing innovation and responsible design, through collaboration between universities and industry. The project brings together international manufacturers in the polymer processing sector and academic researchers, with the aim of leveraging the potential of advanced injection moulding. In this context, the PLEIADES project is in line with European strategies and the Safe and Sustainable by Design (SSbD) framework, which promotes materials and processes designed from the outset according to criteria of durability, recyclability, and reduced environmental impacts.

The collaboration began when the companies Ewikon and Uniform, after learning about the Good Plastic research conducted by the Università Iuav di Venezia, proposed launching a joint initiative. Good Plastic (Badalucco et al, 2022) investigated how the sustainability of a polymer product not only depends on the material used but, especially, on its useful life. In line with studies in ecodesign, and anticipating future regulations (European Union, 2024), the research developed a toolkit for designers. The operational objective of the new PLEIADES project was therefore to experiment with design activities based on a technical brief capable of highlighting the technological and sustainability-related qualities of the components and machinery used, for demonstration purposes. Among the aspects to be highlighted were sprueless injection moulding, the production of three different components in a single mould, and real-time control of production parameters. The Università Iuav di Venezia was therefore asked to design a product that could serve as both a technological demonstrator and a promotional item.

The project involved approximately 100 students from the Degree Programme in Design at the Università Iuav di Venezia (Vicenza campus), who were

tasked with developing proposals based on the Good Plastic toolkit and ecodesign guidelines. Thirty-eight concepts were developed using recycled or recyclable polymers, aimed at showcasing the technologies of partner companies and creating objects of practical utility. One of the presented projects was then selected for production.

The winning project, a cable winder for mobile devices inspired by the donut, is a simple, playful, and functional object. These characteristics make it more likely that the product will be kept and used over time, extending its life cycle and reducing the risk of early discard.

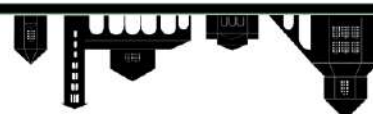
The PLEIADES case shows that the integration of materials research, process innovation, ecodesign criteria, and life-cycle assessment criteria can result in tangible products combining use value, perceived quality, and reduced environmental impacts, confirming the strategic role of design in developing sustainable products aligned with the transition toward a circular (bio)economy.



Figure 1. Production process of the best project: DONUTella

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Rapid Enzymatic Screening of Polymer Biodegradability for Sustainable Packaging Applications

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Keywords: Packaging, Plastic Biodegradation; High-throughput Screening Assay; Enzymatic Hydrolysis

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The global imperative to mitigate plastic pollution has accelerated the development of biodegradable alternatives, yet the inherent complexity of natural biodegradation remains a significant barrier to rapid innovation. This biological process relies on specific microbial enzymes to break down polymer structures, a reaction governed by the interaction between material properties—such as polymer crystallinity and additive composition—and environmental variables including pH, moisture, and temperature. Despite rapid advances in materials science, the lengthy cycles required for standardized biodegradation testing often hinder the commercialization of these polymers. Current certification standards, such as the requirement for 90% biodegradation within a maximum of 12 months (as per the OK Home Compost certificate from TÜV Austria), create a substantial bottleneck in the product development cycle. To address this inefficiency, we propose a novel enzymatic assay designed to quantify reaction rates and identify polymer candidates with high intrinsic biodegradability. By optimizing catalytic conditions, this method accelerates degradation processes that typically requiring days or weeks into a timeframe of several hours.

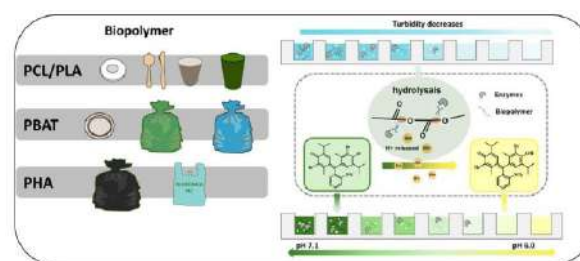
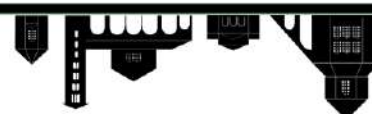


Figure 1. Graphical abstract. The scope of rapid enzymatic screening

This high-throughput screening tool serves as a rapid preliminary evaluation method, enabling efficient selection of high-potential materials and significantly shortening the pathway toward sustainable materials.



Testing durability of next-generation marine composites on a racing yacht: bridging performance and circularity

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Fiber-reinforced polymer (FRP) composites offer outstanding performance, durability, and design flexibility, and are therefore widely used in key sectors including aerospace, renewable energy, and infrastructure. However, their widespread adoption also raises important challenges in terms of end-of-life management. In this context, the integration of eco-design principles, together with recent advances in thermoplastic resin systems, is enabling the development of recyclable composite materials, opening new pathways toward circularity.

Within this transition, the nautical sector, which is characterized by extensive use of composites and strong performance requirements, can act as a real-world testbed for innovative solutions, particularly in high-performance contexts such as racing.

Building on this perspective, a collaboration between the University of Milano-Bicocca and Maccaferri Futura has been established to explore and test novel composite solutions with enhanced sustainability profiles. In addition to recyclability, a key aspect of the project is the design of an experimental set up aimed to better understand the key drivers that affect the durability of materials under realistic environmental conditions, which remains critical for both performance and lifecycle optimization.

The experimental plan is designed to assess material behavior under a range of environmental stressors, including UV radiation, seawater immersion, thermogravimetric cycling, and mechanical fatigue. A distinctive feature of the project is the use of a Class40 racing yacht as a mobile experimental platform, enabling in situ exposure under real marine conditions, complemented by controlled laboratory and testing on diverse marine research facilities.

Materials under investigation include both conventional thermoset composites (e.g., epoxy/glass fiber systems) and emerging recyclable solutions including also biobased solutions, developed by industrial partners such as Northern Light Composites (<https://northernlightcomposites.com/>). Testing is

conducted also on the reference pristine samples and artificially aged materials. The analytical approach is based on a multi-analytical framework combining complementary techniques to capture chemical, thermal, and morphological evolution across scales. These include infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), mass spectrometry (including headspace-SPME-GC/MS), scanning electron microscopy with microanalysis (SEM-EDS), X-ray fluorescence (XRF), and chemometric data processing for multivariate interpretation.

This poster presents the project concept, experimental design, and preliminary results,



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Insights and roadblocks in terephthalic acid upcycling with *Saccharomyces cerevisiae*

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Associated conference session: 4

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Yeasts are robust hosts for large-scale chemical fermentations, especially for the production of organic acids, considering their ability to withstand their presence. In this work, we explored *Saccharomyces cerevisiae* as a microbial cell factory towards the upcycling of terephthalic acid (TPA), a primary monomer of polyethylene terephthalate, into protocatechuic acid (PCA), a chemical of interest for cosmetic formulations. While bacterial TPA catabolism is well-documented, research on yeast-based biotransformation remains scarce.

Our findings show that wild-type *S. cerevisiae* is highly tolerant to TPA (up to 10 g L⁻¹), however deletion of the ABC transporter PDR12 increases sensitivity. This demonstrates Pdr12 involvement in TPA export and largely accounts for the intrinsic TPA resistance of yeast, with only limited passive membrane permeation. To enable the conversion of TPA to PCA, *S. cerevisiae* was engineered to express two different bacterial TPA dioxygenases (TPA-DO) and DCD dehydrogenases (DCD-DH), from either *Ideonella sakaiensis* (Yoshida *et al.*, 2016) or *Comamonas sp.* strain E6 (Sasoh *et al.*, 2006). Engineering strategies included codon optimization, genomic integration and epigenomic expression through plasmids with bicistronic expression units.

Despite the successful expression, no functional conversion of TPA to PCA was detected. We hypothesize that one of the primary roadblocks may be the maturation of TPA-DO, a Rieske non-heme iron dioxygenase that requires a specific iron-sulfur (Fe-S) cluster for functioning (Kincannon *et al.*, 2022). Despite genetic interventions to disrupt iron homeostasis, the enzymatic pathway remained inactive. These findings highlight a previously unrecognized limitation and suggest a fundamental incompatibility between bacterial Fe-S enzyme requirements and the yeast cytosolic

protein assembly machinery (Biz & Mahadevan, 2021), suggesting that TPA upcycling in yeast demands further fundamental breakthroughs.

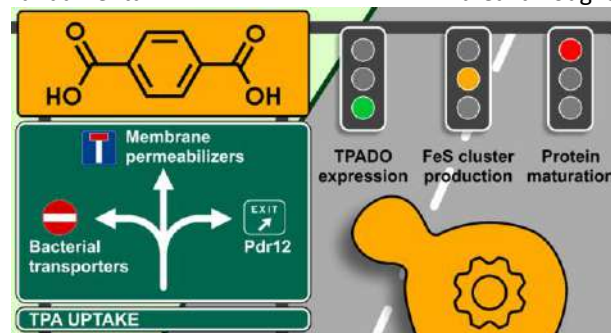


Figure 1. Schematic overview of engineering strategies for TPA uptake and PCA bioconversion in *S. cerevisiae*.

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Microbial upcycling of terephthalic acid into protocatechuic acid via optimized *Pseudomonas putida* fermentation

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Associated conference session: 4
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The accumulation of polyethylene terephthalate (PET) waste presents a critical environmental challenge, driving the need for innovative bioremediation and upcycling strategies. A key intermediate in PET degradation is terephthalic acid (TPA). This study focuses on fermentation strategies applied to a strain of *Pseudomonas putida* engineered to transform TPA into protocatechuic acid (PCA), a high-value antioxidant and pharmaceutical precursor, effectively turning plastic waste into a valuable resource.

An engineered derivative of *P. putida* KT2440 (genotype: *pcaG* Q81*, *ppc* Q74*/W247*, *pykA* Q24*, *pykW* 52*/Q59*, *aroF-I* D159N) was implemented (Volke et al., 2022). This strain is deficient in PCA degradation, ensuring its accumulation as a final product. While previously modified for *de novo* PCA production from glucose, in this work, it was transformed with the pBT-T-phE plasmid bearing the *tph* cluster (*TphA123* and *TphB* from *Pseudomonas umsongensis*) (Hernández-Sancho et al., 2024). This machinery catalyzes the conversion of TPA into intermediate, 2-dihydroxy-3,5-cyclohexadiene-1,4-dicarboxylate (DCD) and subsequently into PCA. This biocatalyst, designated *P. putida* PCA-TPA, was evaluated in microfermentation and 2-L bioreactor scales.

In minimal medium, the strain achieved a 95% molar yield during exponential phase with a volumetric productivity of 0.37 ± 0.04 g/L-h. In an exponential fed-batch process (TPA 20 g/L; Glucose 400 g/L), the strain consumed 11.25 g of TPA within 17 hours, producing 10.15 g/L of PCA (97.2% molar yield). Optimization trials confirmed that reducing glucose (Glucose 50 g/L) in the feed maintained PCA high titers (~10 g/L), significantly enhancing the process's economic potential. Furthermore, a downstream process for PCA purification was proposed.

This study successfully characterizes the efficient biotransformation of TPA using a specialized *P. putida* biocatalyst. These optimized fermentation settings provide a robust for the TPA upcycling derived from the enzymatic hydrolysis of PET, closing the loop in the circular plastic economy.

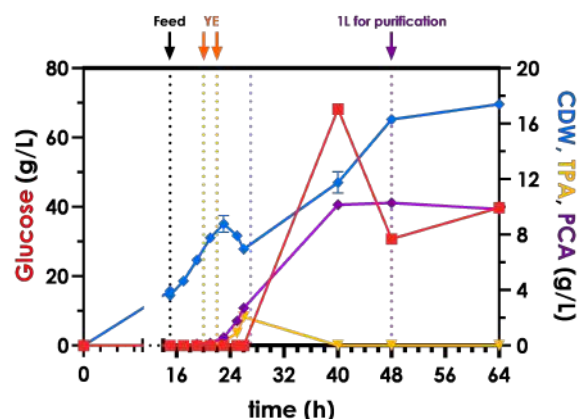
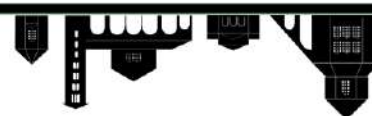


Figure 1. Fermentation profile of *P. putida* PCA-TPA in a 2-L bioreactor using an exponential fed-batch strategy. The left y-axis shows Glucose (red, square) concentration in g L⁻¹, the right y-axis shows CDW (blue, diamonds), TPA (yellow, squares) and PCA (purple, diamonds) concentration in g L⁻¹. The feeding phase is marked with pointed lines, while the arrow indicates the addition of pulses of Yeast Extract (YE).

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Optimization of ethylene glycol upcycling to glycolic acid through yeast biodiversity and process conditions

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Associated conference sessions: 4

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Plastics are indispensable for numerous needs of modern society, and consequently, production is increasing every year; however, plastic waste management is still extremely problematic as only 10% of new plastics are recycled even once, while the remaining portion has landfills or incinerators as its final destination. Of all plastics, polyethylene terephthalate (PET) is the most widely produced polyester in the world, and it has recently been demonstrated that it can be enzymatically hydrolysed, even on an industrial scale, to possibly regenerate the same polymer. However, it would be possible to imagine upcycling to obtain higher value-added molecules, which could offset the cost of the process. Ethylene glycol (EG) is one of the two monomers released by hydrolysis. While most research focuses on bacterial metabolism of EG, we tested the ability of *Saccharomyces cerevisiae* and nine other common yeast species not only to consume EG, but also to produce glycolic acid (GA) as a major by-product (Fig. 1).

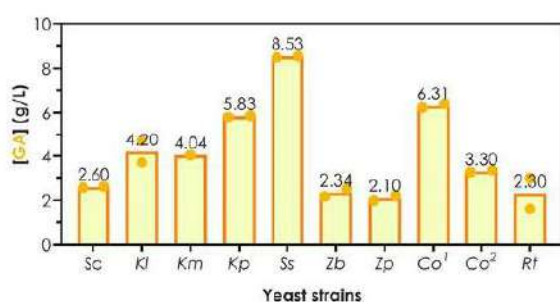


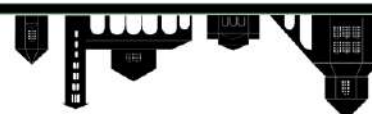
Figure 1 .GA production from EG by non-*Saccharomyces* yeasts. Bars are the mean of two independent experiments; the value of each replicate is represented by a circle; the value of the mean is expressed on top of the bars. Sc, *S. cerevisiae*; Kl, *K. lactis*; Km, *K. marxianus*; Kp, *K. phaffii*; Ss, *S. stipitis*; Zb, *Z. bailii*; Zp, *Z. parabailii*; Co1, *C. oleagnosus* (ATCC 20509); Co2, *C. oleagnosus* (DSM 70022); and Rt, *R. toruloides*.

A two-step bioconversion of EG to GA by *S. cerevisiae* was optimised using a design-of-experiment approach, yielding 4.51 ± 0.12 g l⁻¹ of GA with a conversion of $94.25 \pm 1.74\%$ from 6.21 ± 0.04 g l⁻¹ of EG. Engineering approaches to ameliorate the process have been applied, but elucidating ethylene glycol metabolism in *S. cerevisiae* was challenging. In order to increase performance and process ease, biodiversity screening identified *Scheffersomyces stipitis* as the best GA producer (23.79 ± 1.19 g l⁻¹, 76.68% yield) in bioreactor fermentation with a single-step bioprocess. Interestingly, the product, GA, can find applications in the cosmetics industry, thus allowing the connection of two production chains in a logic of circularity of resources and reduction of high-impact waste.

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Production of microbial oils by oleaginous yeasts for bioplastic applications

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Keywords: microbial oils, oleaginous yeast, molasses valorization, lipid accumulation, bioplastics.

Associated conference sessions: Promoting Safe and Sustainable by Design, circularity and bioeconomy in polymers innovation.

Associated conference sessions: 4

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The increasing demand for sustainable materials has driven interest in microbial-derived plasticizers for bioplastics. This work investigates the production of microbial oils using oleaginous yeasts (*Cutaneotrichosporon oleaginosus* and *Lipomyces starkeyi*) cultivated with second generation raw material, both offering a lower carbon footprint compared to fossil-based sources. Lipid accumulation is induced through nitrogen limitation, enabling the conversion of excess carbon sources into storage lipids.

Batch fermentations with *C. oleaginosus* were conducted first with pure sugar glucose or fructose (25 g/L each) in 2 L stirred tank bioreactors at 30 °C, pH controlled at 6.0, and under aerobic conditions. Complete sugar consumption was achieved within 40 – 44 hours with a final biomass concentration of approximately 20 g/L. Under these conditions, the onset of nitrogen limitation occurred after about 10 hours, leading to a lipid accumulation phase lasting up to 34 hours.

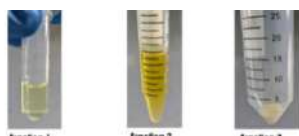


Figure 1. The microbial oil sample, after storage at –20 °C, spontaneously separated into three phases: an upper light phase (Fraction 1), a middle dense phase (Fraction 2), and a lower viscous phase (Fraction 3). Most of the material was concentrated in the middle fraction, while the top and bottom fractions were present in smaller amounts.

Lipid extraction was performed using an optimized chemical method, leveraging bio-based and low impact solvents (Senatore, 2026). The process yielded 8.38 g of oil corresponding to 27 % (w/w) of the cell dry weight. Post-extraction, the oil was separated into three fractions, with the majority of recovered material concentrated in the second one (see Figure 1). Chemical characterization via ASAP-MS (Atmospheric

Solids Analysis Probe–Mass Spectrometry) revealed a consistent fatty acid profile across fractions dominated by linoleic acid (>70%), followed by oleic, linolenic, and palmitic acids.

Subsequently, the process was extended to the use of molasses, which was first characterized in terms of sugar and nitrogen content (see Table 1) to properly set the C/N ratio, a key parameter for lipid accumulation. Since *C. oleaginosus* cannot metabolize sucrose, an acid hydrolysis step (Kieselev, 2022) was optimized to ensure full sugar availability. We showed that molasses can also provide components (i.e. vitamins, trace elements or salts) that must be added separately when using minimal media. In addition, the potential of molasses as a low-cost substrate within a circular economy framework has been further highlighted by demonstrating the accumulation of microbial oils by the selected yeasts using sugar beet molasses in lab-scale fermentation set-up.

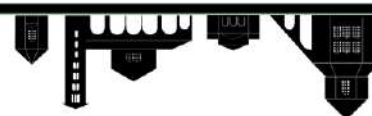
Table 1. Sugar and nitrogen content in beet molasses.

Component	Concentration (g/L)
Glucose	12
Fructose	18
Sucrose	601
Nitrogen	0.3

This work was supported by the European Union's Horizon 2020 Research and Innovation Programme under grant agreement number 101036838, by the Ministero dell'Istruzione e del Merito (MIUR) PRIN number 2020SBNHLH.

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From source to resource: recovery and biotechnological valorisation of textile microfibres from domestic appliances

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Keywords: PET, TPA, cotton, textile waste.

Associated conference sessions: 4

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Domestic laundering is a major source of textile microfibres (MFs) entering aquatic environments (Luzi *et al*, 2025), with wastewater treatment plants acting as convergence points (Carnevale Miino *et al*, 2024). Reducing this load requires effective interception strategies at the source.

We investigated different combinations of household appliances, including washing machines, tumble dryers and outlet filtration systems, to assess their role in microfibre mitigation. Our results show that the combined use of tumble dryers and washing machine outlet filters can retain a substantial fraction of fibres otherwise discharged to wastewater, significantly reducing their transfer to treatment plants (Table 1). These appliances therefore represent not only mitigation tools, but also accessible and decentralised recovery points for textile microfibres.

enzymatically hydrolysed using cellulases to release fermentable sugars, achieving conversion yields >90%. PET fibres were thermally pretreated to reduce crystallinity and enhance their susceptibility to depolymerisation by an engineered variant of leaf-branch compost cutinase (Δ LCC), developed to operate efficiently at 37 °C (Pirillo *et al*, 2023), yielding terephthalic acid (TPA) and ethylene glycol with conversion yields >90%. The recovered TPA was subsequently utilised by engineered microorganisms to produce high value-added compounds, demonstrating the feasibility of converting heterogeneous textile microfibres into valuable biochemical products (Rosini *et al*, 2025; Zangelmi *et al*, 2026).

This work was supported by the Fondazione Cariplo grant “ProPla: proteins from plastics” 2022-0631.

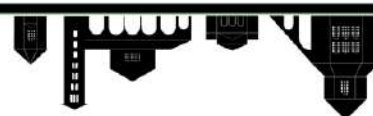
Discharge to the WWTP	Appliance	Release (mg/kg of textile)
High	Combined washer and dryer	428.97 ± 179.54 for cotton towel
		63.14 ± 22.22 for fleece blankets
Low	Washing machine + tumble dryer + external MFs filter	18.9 ± 3.78 for cotton towel
		2.7 ± 3.85 for fleece blankets

Table 1. Comparison between microfibers discharge to the sewerage system using different combination of laundry appliance. WM: washing machine.

Within the ProPla project, we established an integrated biotechnological process for the valorisation of recovered fibres. Cotton microfibres were

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Hydrophilic polysaccharide coatings for ice adhesion reduction

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Keywords: polysaccharide, low adhesion, hydrophilic, coating.

Associated conference sessions: 4

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Ice growth and accumulation represent a serious issue in various industrial sectors where it can lead to performance loss and safety risks. Currently, the most used ice-removal methods are based on thermal, mechanical, and chemical approaches which are time- and energy-consuming as well as environmentally unfriendly. A promising alternative is to complement these active methods with passive approaches by directly modifying the physical properties of surfaces. For this purpose, hydrophobic and superhydrophobic surfaces have been developed and demonstrated to efficiently remove water. However, they may fail in humid conditions. An alternative exploits hydrophilic surfaces in which has been suggested that the formation of weak interactions between the substrate and water molecules at the interface may result in the formation of the so-called quasi-liquid layer, potentially reducing ice adhesion (Sadtschenko et al., 2022).

In this work, we explore the potential of hydrophilic coatings as icephobic materials by exploiting chemically different polysaccharides, biopolymers rich in polar groups able to generate weak bonds with interfacial water (Marelli et al., 2025), including chitosan, hyaluronic acid, pullulan, tamarind seed polysaccharide (TSP) and sulphated TSP.

Polysaccharide monolayers were prepared using smooth glass slides coated with a nitrene-generating commercial adhesion promoter as substrates. Polysaccharide-coated surfaces were characterized by contact angle measurements through a quasi-static contact angle analysis in which advancing (θ_a) and receding (θ_r) angles were measured and by ice adhesion tests to evaluate the shear stress required to detach ice from the surface (Figure 1).

All polysaccharide coatings showed a marked difference in wettability compared to the reference glass slide coated by the adhesion promoter ($\theta_a = 62 \pm 4^\circ$). The most hydrophilic coatings were hyaluronic acid ($\theta_a = 14 \pm 2^\circ$), pullulan ($\theta_a = 11 \pm 2^\circ$), TSP ($\theta_a = 17 \pm 2^\circ$),

and sulphated TSP ($\theta_a = 21 \pm 2^\circ$), while chitosan ($\theta_a = 86 \pm 4^\circ$), is observed to be a relatively more hydrophobic. All samples showed a $\theta_r < 10^\circ$. In terms of ice adhesion, the most promising results were obtained for sulphated TSP, pullulan and hyaluronic acid samples which provide significant reduction of ice adhesion at -6°C , up to $\tau = 323 \pm 82$ kPa for sulphated TSP, $\tau = 79 \pm 46$ kPa for hyaluronic acid and $\tau = 206 \pm 54$ kPa for pullulan compared to reference glass coated with adhesion promoter ($\tau = 402 \pm 35$ kPa).

This work sets the basis for an improved understanding of physical interaction at interfaces between ice and substrates and potential application as environmentally friendly surface coating. Further studies will be conducted with different substrate, such as silicon, to evaluate the effect of the substrate in ice adhesion and to measure the thickness of the polysaccharide coating through ellipsometry.

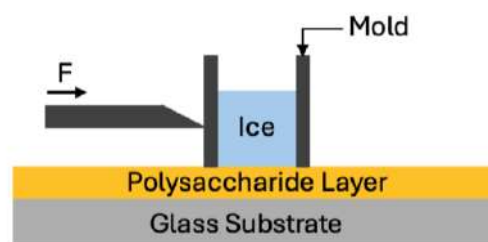
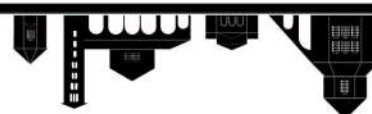


Figure 1. Illustration of custom-built horizontal shear test set up used for ice adhesion tests.

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From Microplastic Hotspots to Solutions: Leveraging Wastewater Treatment Plants for PET Valorization and Emission Reduction

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Associated conference sessions: 4

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Wastewater treatment plants (WWTPs) are increasingly seen as crucial points for reducing microplastic (MP) emissions, although their potential for recovering polymers is still largely unexplored. Among microplastics, micro-polyethylene terephthalate (micro-PET), primarily originating from synthetic textile fibres, can be considered a valuable secondary raw material, WWTPs could so help recover valuable materials like micro-PET from textile fibres.

This study examined how microplastics behave and can be removed or recovered during different treatment stages. Pile cloth filtration effectively removed about 67% of microplastics, while mechanical dewatering removed around 50%, acting as a barrier to their release. Anaerobic digestion had little impact on microplastic levels. Certain water streams showed high microplastic concentrations and could serve as starting points for recovery. Micro-PET was found in filter wash water, but its absence in dewatering water suggests that applicability depends on wastewater composition and treatment conditions. The developed method successfully isolated micro-PET even in complex samples. Overall, combining microplastic removal with material recovery could support more sustainable wastewater management.

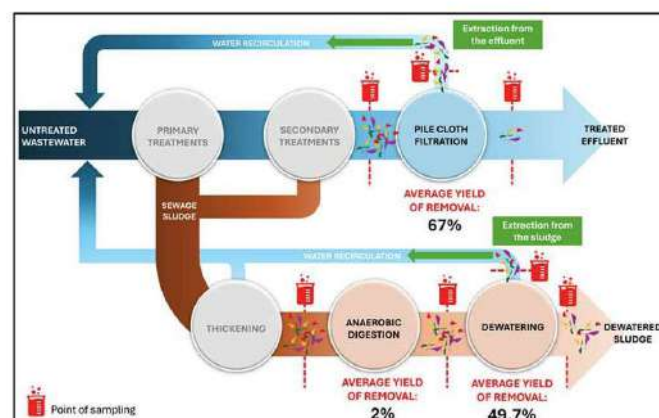
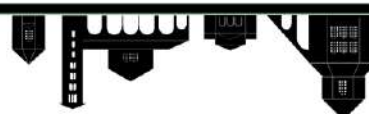


Figure 1. Graphical abstract

This work was supported by the Fondazione Cariplo grant “ProPla: proteins from plastics” 2022-0631.

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Options for riverine plastic waste collected in Motława river (Poland)

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Keywords: ocean-bound plastic, chemical recycling, Motława river, marine plastic pollution, plastic collection

Associated conference sessions: 4

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Plastic debris entering seas and oceans originates from both land- and sea-based sources and progressively breaks down into microplastics. Approx. 80% of marine plastic pollution is land-derived, particularly from urban areas, and is transported primarily through rivers, canals, and harbours (Meijer *et al.* 2021). Given the complex and transboundary nature of this issue, it is essential to address the full lifecycle of marine plastic waste, from its sources and monitoring to its collection, recycling, and reuse (Gontarek-Castro *et al.* 2026).

A range of waste management strategies can be applied to marine plastics, including reuse, mechanical and chemical recycling, solvent-based extraction, energy recovery, and biodegradation. The appropriate approach depends on factors such as polymer type, degree of degradation, contamination level, and available infrastructure. Mechanical recycling is the most widely used method, especially for relatively homogeneous polyolefin waste. However, its efficiency declines when plastics are degraded or contaminated. In such cases, chemical recycling methods, such as glycolysis, pyrolysis, or hydrothermal liquefaction, provide alternative pathways by converting polymers into valuable monomers or petrochemical feedstocks (Gontarek-Castro *et al.* 2026).

Within the *Circular Ocean Plastic (COP)* project, riverine plastic waste was collected from river in Gdańsk and recycling approaches were investigated to valorize these streams. Due to high contamination solvent-based recycling of polyolefins (polypropylene - PP and high-density polyethylene - HDPE) was examined using environmentally friendly solvents to selectively dissolve and purify polymer fractions from contaminated waste. In addition, chemical recycling strategies were explored for polyethylene terephthalate (PET) bottles present in marine litter.

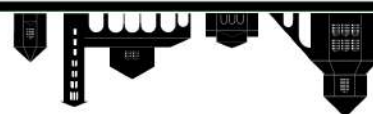


Figure 1. Collected waste fractions from Eco-kayak action in Gdańsk, Poland.

This work was funded by the Interreg South Baltic Programme 2021–2027 within the project “Circular Ocean-bound Plastic” (No. STHB.02.03-IP.01-0006/23-00). Project co-financed by the Polish Ministry of Science and Higher Education under the programme Co-financed International Projects (No. 6101/INTERREG VI-A/2024/2025/2).

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Innovative Low-Friction Coatings for Synthetic Fabrics: Preventing Microplastic Pollution at the Source

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Keywords: Microplastic, Microplastic Fibres, SCALS, PDMS, Sustainable Coatings.

Associated conference sessions: 4

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Microplastic are solid, water-insoluble particles smaller than 5 mm resulting from the degradation of large plastic components. Due to their high persistence, these pollutants accumulate in diverse environments globally and inevitably penetrate the food chain. This trophic transfer ultimately leads to human exposure, as evidenced by the measured presence of microplastics in the circulatory system, with potential toxicological effects that remain unclear and are currently the subject of intensive medical research (Leslie et al., 2022). A primary source of microplastic release into aquatic systems is the domestic laundering of synthetic textile. During washing, microplastic fibres are generated through fabric abrasion caused by the friction between yarns; therefore, reducing this friction is a key strategy for mitigating fibre shedding. To this end, applying soft micro or nanometric low-friction coatings can facilitate fibre sliding and minimize mechanical stress. (Lahiri et al., 2023)

Slippery Covalently Attached Surfaces (SCALS) consisting of a layer of liquid polymers or oligomers chemically bonded to a substrate have emerged as a highly effective solution. These surfaces utilize high chain mobility to provide exceptional lubrication, hydrophobicity and reduced adhesion.

Polydimethylsiloxane (PDMS) is frequently utilized in SCALS due to its biocompatibility, low toxicity and low glass transition temperature, which maintains chain mobility even at sub-zero temperature. Furthermore, it is a non-fluorinated material and therefore potential replacement of several PFAS coatings which are rising substantial environmental and toxicological concern. (Gresham et al., 2025)

Current research demonstrates that functionalizing nylon-6,6 fabrics with a primer followed by PDMS chains can reduce fibre shedding by $93 \pm 2\%$ without compromising the fabric's hydrophobicity, surface structure or comfort (Lahiri et al., 2023). However, current methods rely on multi-step processes involving primers or chemical reactions involving the

use of toxic chemical to promote adhesion. My research aims to streamline the functionalization process by directly grafting short-chain coatings onto the textile surfaces, reducing reagent consumption and employing eco-friendly precursors to achieve a more sustainable and efficient anti-shedding treatment.

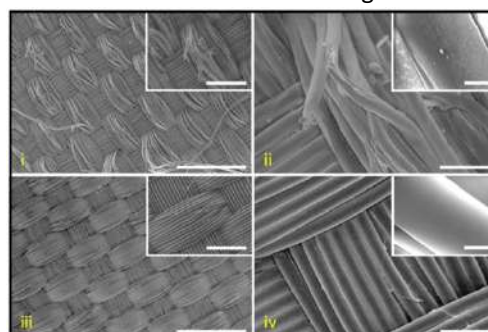
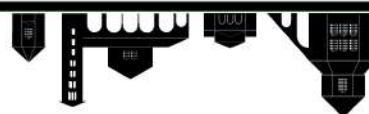


Figure 1 SEM images of untreated (i, ii) and SCALS treated (iii, iv) nylon-6,6 fabrics after nine mild washing cycles. (Lahiri et al., 2023)

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The ProPla project: A Patent Landscape Analysis of the main technological trends for the microPET conversion into value-added products.

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Keywords: Microplastics, Wastewater, Amino acids, Circularity, Innovation.

Associated conference sessions: 4

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The unsustainable use and disposal of plastics is causing persistent and widespread environmental contamination.

In particular, the pervasiveness of microplastics (MPs) in wastewater has become a major environmental issue in aquatic ecosystems and may cause adverse health effects for humans and other living organisms.

In this scenario, the Protein from Plastic (ProPla) project, funded by Fondazione Cariplo, aims at developing an innovative biotechnological application to recover PET microplastics (microPET) from wastewater and exploit the power of protein engineering and system biology approaches to generate a novel bacterial strain able to convert microPET into amino acids, that can be used in many industries (food, cosmetics, etc.) in a circular bioeconomy perspective.

This paper presents the socio-economic framework of the ProPla project, which includes a patent landscape analysis (PLA) and a socio-economic assessment, aimed at highlighting the system of values and the economic opportunities embodied in the process.

The PLA was crucial in mapping the main technological trends related to the ProPla process, highlighting opportunities with significant economic potential for the isolation of MPs from water, their characterization and the development of a novel *E. coli* strain for the conversion of PET into amino acids.

In particular, the main aim of the PLA is to provide an overview of the technological “state of the art” and of the main innovative emerging trends concerning:

1. The isolation of MPs from water and their characterization.
2. The development of a novel *E. coli* strain for conversion of microPET degradation products into amino acids.

The PLA was conducted in accordance with the guidelines prescribed by the World Intellectual Property Organisation (Trippe, 2015), through a patent search strategy that combined a series of queries based on the most relevant patent text keywords and of the most relevant technological IPC/CPC patent classes.

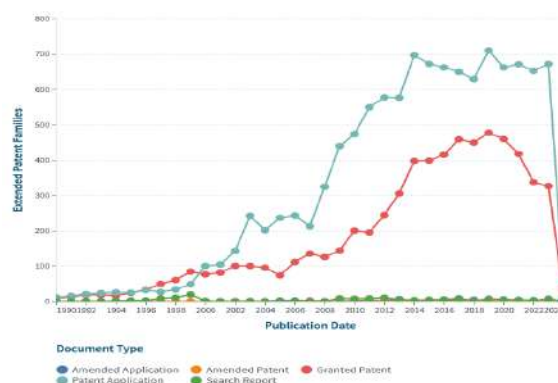


Figure 1. N. of extended patent families by doc type.
Source: Own elaborations using data from lens.org.

The socio-economic assessment aimed at underlining the multiple direct and indirect values arising from the project outcomes and products.

The issue of the economic feasibility of microPET conversion into value-added products was examined, together with the evidence of the potential social and economic benefits coming from the valorisation of microPET by way of a bio-based conversion process.

Finally, an impact analysis has been developed to emphasize the contribution of the overall project results in the achievement of SDGs, at a public level, and of ESG, at a firm level.

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Metabolic engineering and *in silico* modelling of ethylene glycol assimilation in *Saccharomyces cerevisiae*.

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Keywords: metabolic coupling, ethylene glycol, selection strain, *in silico* modelling

Associated conference sessions: 4

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The widespread use of polyethylene terephthalate (PET) in packaging has led to urgent environmental challenges, driving the need for circular bioeconomy solutions. This study explores the potential of ethylene glycol (EG), one of the PET derived monomers, as a carbon source for the yeast *Saccharomyces cerevisiae*.

While EG metabolism has been uncovered in bacteria, in yeasts, EG oxidative pathway has only been proposed (Senatore et al. 2025). Furthermore, previous studies showed that *S. cerevisiae* primarily converts EG into glycolic acid (GA) while forming the toxic intermediate glycolaldehyde (GAH). In fact, when GAH is added to the medium as the initial substrate, cells mainly detoxify GAH into EG and, in a minor scale, oxidase it to GA, creating a dynamic equilibrium among the three molecules (Senatore et al. 2025). Time-course data were used to model reaction dynamics with *ODEs*, and a custom *Particle Swarm Optimization* approach was used to estimate reactions directionality.

To mitigate GAH-associated toxicity and promote EG assimilation, we employed a metabolic engineering strategy introducing the Tartronyl-CoA (TaCo) pathway in *S. cerevisiae*. With this strategy, as previously reported in bacteria (Scheffen et al. 2021), GAH derived from EG is funnelled into the glycolytic intermediate 2-phosphoglycerate (2PG). To impose a metabolic dependency, the gene encoding phosphoglycerate mutase (GPM1) was deleted, aiming for the coupling of yeast growth with the consumption of EG-derived 2PG (CER.TaCo Δ *gpm1* strain).

While EG increased the final biomass of the tested strains relative to the same strains grown in the same medium without it, a medium with EG as the only carbon source did not support biomass formation. Moreover, strains expressing the TaCo pathway exhibited significantly higher EG consumption rates and reduced GA production yields compared to controls.

These results suggest that the heterologous pathway may outcompete endogenous redox reactions. Moreover, our results point to the potential of synthetic bypasses to redirect non-conventional carbon sources into central metabolism, with possible applications in using PET-derived molecules as feedstock for yeast-based biomanufacturing.

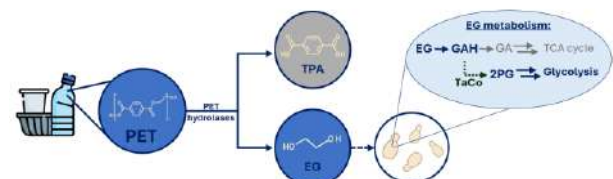


Figure 1. Metabolic engineering strategy for EG assimilation into central metabolism in *S. cerevisiae*.

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Safe and Sustainable by Design Approach for Lapis Lazuli Fine Stone Filler Toward Advanced Polymer Composite Applications

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Keywords: Lapis lazuli, ceramic filler, polymer composites, Surface morphology, Particle size.

Associated conference sessions: 4

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Abstract

The rising demand for sustainable and functional materials has increased interest towards natural mineral-based fillers for polymer composite applications. A study was conducted to characterize lapis lazuli as a new ceramic filler material for future reinforcement in polymer fibre composites. The evaluation of the suitability of lapis lazuli powder as a functional filler was done by different characterization techniques. Scanning electron microscopy (SEM) was used to examine the surface morphology and particle distribution, whereas energy-dispersive X-ray spectroscopy (EDS) was used to assess the elemental composition. The crystalline phases and mineralogical structure were analyzed via XRD, while the thermal stability was analyzed via TGA. The material was analysed for its optical properties using UV-Visible spectroscopy, its particle-size distribution and colloidal behaviour using Dynamic Light Scattering (DLS), and its nanoscale surface topography using Atomic Force Microscopy (AFM). The preliminary results show that lapis lazuli has a stable mineral composition; it has also shown good thermal resistance. This material has been determined to have unique optical absorption behaviour; it also has a controlled particle size distribution and irregular surface morphology, which make it suitable for filler application. The presence of aluminosilicate-rich phases may be compatible with polymers. The authors present the baseline material data for lapis lazuli and suggest its possible use as a reinforcement filler in polymer fibre composite systems for engineering applications.

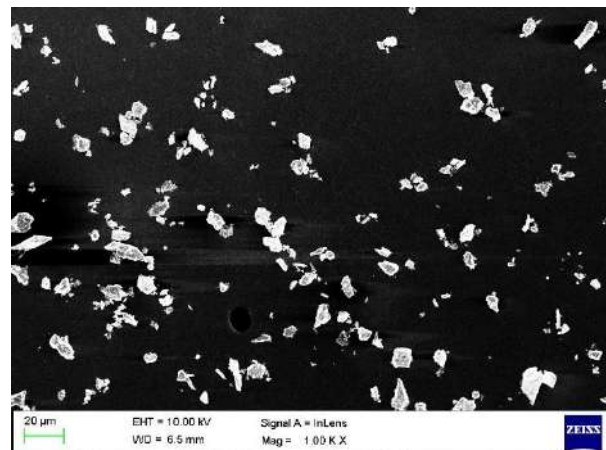


Figure 1. SEM micrograph of lapis lazuli filler particles (1000× magnification) showing irregular morphology and particle dispersion

Acknowledgement: The authors sincerely thank the management of Alliance University, Bengaluru, India, for providing the necessary research facilities and financial support.

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Advanced SSdD-Based Antimicrobial Textiles Using Silver Nanoparticles and Egyptian Blue

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Keywords: PES textiles, antimicrobial activity, LCA, multioptimization, SSdD.

Associated conference sessions: 4

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The global demand for high-performance functional textiles has intensified the need for antimicrobial solutions that do not compromise environmental integrity. In this study silver nanoparticles (AgNPs) and the historical pigment Egyptian Blue (EB) were investigated as two distinct antimicrobial strategies, each applied as a sol-gel coating onto the surface of polyester (PES) textiles.

Within an SSdD-oriented framework, the study combines functionality, controlled release, and environmental exposure considerations across relevant lifecycle stages (Figure 1). Beyond antimicrobial efficacy, at the material and product level (coated textile), the use phase is investigated through ISO-standardised leaching tests to quantify nanoparticle release, alongside durability assessments of antimicrobial performance. The approach spans from the green synthesis of AgNPs and EB (Blosi et al., 2024; Nicola et al., 2024) to their optimised incorporation via advanced coating processes (Furxhi et al., 2024), and extends to end-of-life aspects, addressed through modelling of nanoparticle fate in landfill scenarios (Furxhi et al., 2025).

Within an SSdD-oriented framework, the work focuses on the integration of functionality, controlled release, and environmental exposure considerations across key lifecycle stages.

To enhance biocidal efficacy, a simplified Design of Experiments (DoE)-based matrix was used to support a structured optimisation process. This approach relied on a limited number of experimental points and was applied in two stages: first, to screen key nanoparticle synthesis parameters, and second, to refine textile functionalisation conditions. Experimental results on E.coli and S.aureus demonstrated antimicrobial reduction exceeding 99.99% for both treatments. The observed performance was tentatively correlated with key physicochemical descriptors, including particle size,

surface coating characteristics, and for EB far-infrared (FIR) luminescence, providing insights into the underlying functional mechanisms.

By aligning antimicrobial performance with SSdD principles, this approach enables the development of scalable coating solutions that anticipate future regulatory requirements while reducing potential environmental impacts.

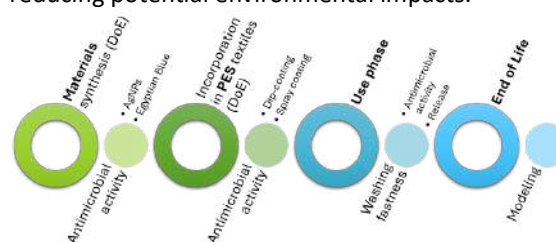


Figure 1. Workflow of PES coated textiles.

This work was supported by European Union's Horizon Europe research and innovation programme under GA No 862444, ASINA project and GA No 101138414, INTEGRANO project.

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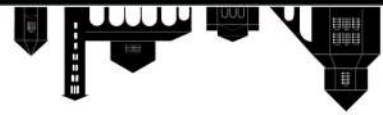
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Session 5 – “Plastics and climate-neutral cities. Rethinking practices, governance and politics for urban and environmental health”



Oral Presentations



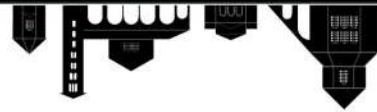


Keynote: Luigi Pellizzoni - SNS

Title: Beyond plastic futures

Abstract:

Plastics are extremely useful, hence widespread materials, which however present two problems: they are part of the fossil fuel product chain, hence indirectly contribute to climate change, and they are persistent in the ecosystem, leading to ecological and health issues. The problems that arise from this are emblematic of a wide range of technologies and seem to be addressable in two ways: reducing the production and use of plastics, giving up to a certain extent the benefits they provide, or increasing their recycling and reuse, with related costs and difficulties. The problems both solutions present can be traced back, on the one hand, to the idea of degrowth and, on the other, to the idea of the circular economy. "Politicising" the latter, in the sense of asking how technical solutions interface with the social and economic context, as some propose, is useful in showing the need for a governance of innovation. In my presentation, I will focus on three aspects: a) the issue of basic needs and consumption corridors as a side route to the alternative between growth and degrowth; b) the issue of the governability of the future and therefore of uncertainty with regard to technologies and their impacts; c) the relationship between voluntarism and nudging in the sphere of everyday practices. Going beyond a plastic future, as the title suggests, means both thinking about a future with less (new) plastic and thinking about the plasticity of the future in a different way than usual.



Invited Speaker: Ing. Alberto Pizzocchero – Circular Economy Expert Direzione Lavoro, Giovani e Sport - Comune di Milano

Title: New circular policies for the City of Milan.

Abstract:

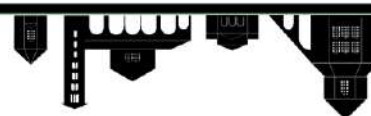
The speech will focus on how the Municipality of Milan is designing and activating policy instruments and strategic frameworks to support the transition toward a more circular and carbon-neutral city. Framed within the socio-technical dimensions of urban environmental transitions, the contribution focuses on Milan's approach to the circular economy as a tool for reducing climate impacts, resource consumption and waste generation through public governance. Particular attention is paid to the city's predominant sectors—**fashion and design**—where materials such as plastics are deeply embedded in value chains, everyday practices and power relations. By combining regulation, incentives, partnerships and measurement tools, Milan positions itself as an urban laboratory for circular innovation, public engagement and just transitions toward sustainable urban futures.

**Invited Speaker: Massimo Di Domenico - Settore Ambiente, Acqua ed Energia
di Confservizi Lombardia**

Title: Plastics and Climate-Neutral Cities: Governance, Circular Practices and the Role of Waste Utilities in Urban Environmental Health

Abstract:

Achieving climate-neutral and plastic-free cities requires not only technological innovation, but also a profound transformation in urban governance, institutional coordination, and environmental practices. In this transition, waste management companies and treatment facilities should be recognised as central actors in shaping more circular and resilient urban systems. Traditionally associated with collection and disposal services, waste utilities are increasingly assuming a strategic role in preventing plastic leakage, improving material recovery, and supporting circular economy models at the local level. Through separate collection schemes, advanced sorting and recycling infrastructures, and recovery plants, these actors contribute to reducing greenhouse gas emissions linked to virgin plastic production and unsustainable waste disposal pathways. Beyond their operational function, waste management enterprises play a crucial governance role by supporting municipalities in the design and implementation of policies aimed at reducing single-use plastics, promoting reuse practices, and improving urban environmental health. Their territorial knowledge, industrial capacities, and data on material flows make them essential partners in the development of evidence-based urban policies and integrated climate strategies. This oral communication explores how the governance of plastics in cities can be strengthened through closer cooperation between local institutions, utilities, treatment plant operators, and citizens. Particular attention is devoted to the political and organisational dimensions of the transition, highlighting how climate-neutral urban futures depend on robust waste infrastructures and on governance models capable of integrating environmental, industrial, and public health objectives. The contribution argues that plastic-free cities should be understood not only as a behavioural or regulatory challenge, but as the outcome of coordinated circular governance systems in which waste utilities play a decisive role.



Microplastics in Lombardy's waterbodies: an environmental and social concern

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¹Lombardy Energy Cleantech Cluster, Milan, Postcode, Italy

²Lariana Dépur, Lomazzo, Postcode, Italy

Microplastics (MPs) originate from many products (cosmetics, synthetic fabrics, disposable plastics, tires, etc.) and from the improper disposal of plastic waste. MPs have been found worldwide in every environmental compartment at highly variable concentrations (Pal, 2025).

This contribution provides an overview of the presence of MPs in Lombardy's waters (situated in Northern Italy), comparing it with other significant Italian findings. In Lombardy, microplastics have been detected in major rivers and lakes, with levels varying according to anthropogenic pressures and the degree of urbanization of the surrounding area (GdL-MIE, 2020; GdL-MIE, 2025). In these studies, a central role is played by the Universities of Milan and Milan Bicocca, which develop monitoring methodologies and conduct studies on numerous water bodies.

However, the presence of MPs in wastewater and sludge in Lombardy is not yet subject to systematic monitoring by regulatory authorities or Integrated Water Service operators. Assessing the presence of MPs in treatment plants, in relation to variations in catchment characteristics, treated flow rates, pollution sources and treatment processes, is of strategic importance for understanding and managing this type of pollution. Within this context, some critical issues of representativeness have already emerged in river monitoring, where seasonality and flow variations significantly influence results, making it difficult to interpret the data without a solid understanding of the hydrological regime.

In general, the data currently available on MPs highlights social and governance risks that involve producers.

Regulators are increasingly treating MPs in the same way they treat greenhouse gas emissions or toxic

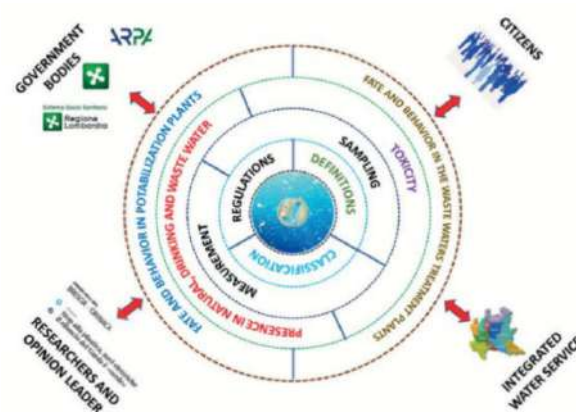


Figure 1. Schematic picture of environmental and social concern of microplastics (GdL-MIE, 2020).

chemicals, considering this pollution a measurable direct responsibility of producers that affects the long-term state of the environment. For this reason, the application of extended producer responsibility may be an effective strategy.

In conclusion, MPs thus represent both an emerging environmental pollution as well as a critical concern for the socio-economic structure of society and a challenge for public policy.

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Plastic pollution and artisanal fisheries: a comparative analysis between the Abruzzo coast and Andaman Sea communities in Thailand (Moken and Urak Lawoi)

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¹Università di Teramo

Keywords: plastic pollution, artisanal fisheries, Moken, Urak Lawoi, marine governance, Mediterranean, Andaman Sea

Associated conference sessions: 5

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Plastic pollution represents a major global challenge affecting marine ecosystems and coastal communities, yet its impacts and management differ significantly depending on socio-economic and cultural contexts. This study compares two distinct but interconnected realities: artisanal fisheries along the Abruzzo coast (Italy) and sea-oriented communities (Moken and Urak Lawoi) in the Andaman Sea, Thailand.

The analysis draws on qualitative research and on empirical insights concerning fisheries-related plastic waste.

In the Abruzzo case, plastic pollution emerges primarily as an externality of global production and waste systems rather than of artisanal fishing practices themselves. Marine litter—especially bottles, polystyrene fish boxes and macro-waste—is largely land-based or linked to industrial maritime traffic. However, regulatory frameworks produce a paradox: plastic collected by fishers is classified as “special waste”, imposing disposal costs and bureaucratic burdens that discourage retrieval and may lead to re-discarding at sea.

This highlights a structural contradiction between environmental objectives and governance mechanisms, where small-scale fishers are simultaneously victims and potential mitigators of pollution.

In contrast, Moken and Urak Lawoi communities historically embody a relational and non-extractive interaction with the marine environment. Their semi-nomadic practices, ecological knowledge and animistic cosmologies frame the sea as a lived, social and sacred space rather than a resource frontier. However, contemporary pressures—marine protected areas, tourism development, state territorialisation and environmental degradation—are disrupting these systems. Conservation policies, often based on strict spatial exclusion, risk marginalizing these communities by separating “nature” from “culture”, thereby undermining sustainable traditional practices.

The comparison reveals a critical convergence: both contexts expose limitations of dominant marine governance rooted in technocratic and territorially fixed approaches.

In Abruzzo, regulation fails to integrate fishers into circular waste management systems; in Thailand, conservation frameworks neglect indigenous ontologies and socio-ecological knowledge. In both cases, policies reproduce a binary logic (exploitation vs. prohibition) that overlooks adaptive, community-based practices.

This presentation argues for a reconfiguration of marine environmental governance that integrates artisanal actors and indigenous perspectives. Recognizing fishers as environmental stewards and valuing indigenous maritime epistemologies may enhance both ecological effectiveness and social justice.

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Urban Living Labs and Participatory Governance to promote alternative circular pathways for plastics

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Keywords: Circular Economy, Grassroots Innovation, Participatory Methods, Urban Transition, Plastics.

Associated conference sessions: 5

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Plastic materials are deeply embedded in contemporary urban socio-technical systems, particularly through everyday consumption practices and material flows such as textiles and packaging, which are largely shaped by linear production models. While cities are increasingly called to address plastic-related challenges, current approaches remain largely focused on waste management and technological solutions (Calisto Friant et al., 2021), often overlooking upstream strategies based on reduction, reuse, and changes in consumption patterns. Advancing circular economy transitions therefore requires supporting alternative models that can reshape how materials are used, valued, and circulated within everyday life (Geissdoerfer et al., 2017; Gravagnuolo, 2022).

This research explores the role of grassroots circular initiatives in promoting alternative approaches to plastics circularity and reduction, involving territories and local communities in an urban living lab (Steen and van Bueren, 2017). The study focuses on the metropolitan city of Bologna (Italy) and is based on the case of a Living Lab (Cuomo, 2022), developed from December 2025 to June 2026 within the NRRP ECOSISTER project. The process involved a participatory governance made of an advisory group of experts (10 subjects), facilitators and practitioners (17 organizations), and was structured in phases of mapping and scouting, participatory activities, co-design, and a final validation and dissemination step. Qualitative methods, including facilitated workshops, mapping exercises, surveys, and group discussions, were used to identify emerging practices, challenges and expectations.

The findings show three prevalent business models, i.e. regenerative, service-based and upcycling business models, though which grassroots initiatives

mainly operate in the use phase of products, promoting alternative circular transition pathways. These models generate both environmental and social value, fostering a culture of reuse and engaging communities in more sustainable behaviours. However, their development and scalability are constrained by structural barriers, including limited access to spaces and infrastructures, weak policy and economic support and incentives, and fragmented governance frameworks that do not fully recognise their contribution to a circular society.

The study contributes to debates on circular economy and urban transitions by showing how bottom-up initiatives can shift attention toward underexplored dimensions of plastics sustainability, such as everyday practices, social innovation, and local organisational models. It also highlights the role of participatory environments in revealing gaps between policy, research agendas, and real-world practices, offering insights for more inclusive and place-based sustainability transition approaches. Overall, the research suggests that addressing plastic-related challenges in cities requires moving beyond end-of-pipe solutions and supporting eco-systemic change through, e.g., multi-actor participatory processes.

This work was supported by ECOSISTER project — Ecosystem for Sustainable Transition in Emilia-Romagna (funded under the National Recovery and Resilience Plan PNRR - Mission 4 - Component 2). Spoke No. 5 — Circular Economy and Blue Economy.

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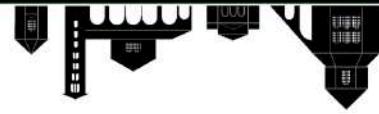
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Session 5 – “Plastics and climate-neutral cities. Rethinking practices, governance and politics for urban and environmental health”



Poster





Defining Plastic Pollution: Framing struggles and regulatory outcomes in the Global Plastics Treaty negotiations

Aurora Nurce

Keywords: Global Plastics Treaty; plastic pollution; framing analysis; INC negotiations; environmental governance.

Associated conference sessions: 5

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The concept of “plastic pollution” doesn’t appear to be universally agreed in practice. Rather than being fixed at a scientific category, it is actively shaped through political negotiations. The way this term is defined could directly influence the kind of obligations that the Global Plastic Treaty will finally deliver at the end of the negotiation process.

This paper takes that definition struggle as a starting point of study and looks at how different understandings of plastic pollution’s concept have been articulated across the five sessions of the Intergovernmental Negotiating Committee (INC-1 through INC-5, convened under UNEP).

The argument of the abstract is that these definition framing are not neutral as they have to be, but reflect competing interests and contrasting visions on how environmental governance should work.

The analysis draws on a close reading of all the draft treaty texts, of the stakeholder submissions, and observations collected during the INC sessions and is grounded in the frame resonance theory (Snow and Benford, 1988). The treaty process is not read only as diplomatic bargaining, but as an arena in which the problem to be governed is being actively constituted (Knoblauch and Mederake, 2024).

Three framing struggles are identified here in this study: First, actors diverge on where the problem is located along the plastic life cycle: a downstream framing emphasizes waste management and recycling, while an upstream framing targets production, product design, and chemicals. Second, growing scientific attention to hazardous additives challenges simplified regulatory approaches that treat plastics as uniform materials. Third, developing countries and informal waste-sector actors highlight the unequal distribution of environmental and economic burdens, questioning solutions that do not address structural inequalities.

Looking at how these different perspectives appear in the draft texts of INC, shows that ambiguity and flexible language are not only products of difficult negotiations but seem to function as a deliberate strategy reflecting different actors’ priorities. This brings to unresolved conflicts within the treaty itself, shifting to future implementation phases and decision-making bodies, where power imbalances are likely to persist.

The study contributes to interdisciplinary debate including political ecology, science, technology studies, and international environmental law. The main argument is both analytical and methodological. To understand what this treaty will actually do in practice, it is not enough to look at the final text alone. It is equally important to pay attention to how the problem it seeks to address has been framed, negotiated, and, in many ways, constructed along the way.

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Energy Transition and Environmental Violence in Sacrifice Zones. The case of Spinetta Marengo Chemical Complex, Alessandria

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In September 2024, the acronym PFAS entered the European public debate. Mario Draghi, presenting the report on the Union's competitiveness, stated that PFAS are necessary for the production of clean technologies, which are fundamental to the so-called *green* and *energy transition*. They are indeed used in photovoltaic panels, wind turbines, and in improving the efficiency of fossil fuel technologies. However, the most compelling justification for their use rests on their role in the hydrogen value chain. Hydrogen is thus the linchpin of the socio-technical imaginaries guiding the energy transition, Jasanoff and Kim (2015), centered on the central and priority role of technological innovation and serving to discursively justify the production of potentially harmful substances. PFAS are in fact considered 'universal pollutants' and have long been recognized at the epidemiological level as Endocrine Disrupting Chemicals (EDCs) (Frisbee et al., 2009).

The issue we raise in this paper lies in the territorial concentration of this harm: PFAS production affects populations and territories already made vulnerable by the pre-existing presence of chemical hubs, thereby exacerbating their "sacrificial" condition (Lerner 2010). This sacrifice is also framed locally as an antidote to the threat of plant closures and unemployment (Mah 2012; Feltrin, Mah, Brown 2022), thereby reinvigorating, in a "green" framework, the supposed trade-off between work and health (Barca 2012). In this context, the energy transition is understood as environmental violence, a form of indirect, structural, and cultural violence intrinsic to the expansive tendencies of capitalism, Stretesky, Long, Lynch, (2013), that produces and reproduces inequality, injustice, and contaminated communities (Edelstein 2004).

Our paper presents the results of an ongoing empirical study in a territory that fits these descriptions: the Spinetta Marengo chemical complex in Alessandria, Piedmont. Active for over 120 years, it has been producing PFAS since the 2000s, when the multinational Solvay acquired ownership. As early as 2007, the European *Perforce* program detected

alarming levels of pollution in the area, McLachlan *et al.*, (2007). Studies by the Italian National Research Council confirmed the disaster, leading to complaints filed by environmental associations with the Alessandria Public Prosecutor's Office, where a criminal trial for environmental disaster is currently underway.

Since 2020, through a *Community-Based Participatory Research*, we have gathered calls for environmental justice, reconstructed the social history of the industry in relation to industrial risk management, and examined the process of transitioning to PFAS chemistry for the energy transition.

The paper will explore two dimensions: the role of the chemical industry in the energy transition, lobbying and the power of expert knowledge in the discursive imposition of socio-technical scenarios and the effects of narrative violence on a territorial scale, the misrecognition of local knowledge and the asymmetric power relations that discursively determine the acceptability of environmental and health damage.

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Recycling as a Political Artefact: When the Numbers Tell a Different Story

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Keywords: plastics, recycling, environmental justice, green economy, methodology.

Associated conference sessions: 5

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Official recycling statistics have long served as the primary metric for evaluating national progress toward sustainable plastic waste management. Yet a growing body of literature highlights a fundamental difference between plastic waste collected for recycling and plastic waste actually recycled. According to the OECD Global Plastics Outlook (2022), only 9% of plastic waste is effectively recycled globally, despite collection rates reported as significantly higher. Process leakages, downcycling, contamination and the systematic offshoring of waste to lower-income countries inflate official figures, producing a methodological virtuosity with deep implications for environmental justice at global levels.

This paper advances a dual argument. First, it questions the methodological foundations of plastic recycling data, drawing on the latest contributions (Ghinea *et al.*, 2023) on reporting inconsistencies in EU packaging waste statistics — highlighting how upstream collection-based measurements systematically overestimate actual material recovery — and on the structural gap between what is declared as recycled and what is demonstrably processed into secondary material. Second, and more critically, it situates these methodological failures within a broader political economy of plastic governance. Building on the Center for Climate Integrity's investigations (2024, 2025) and from an Environmental Justice perspective, it argues that the promotion of recycling as the dominant policy response to plastic pollution has functioned, for over five decades, as a deliberate corporate strategy to deflect regulatory pressure, sustain demand for virgin plastic resins and shift moral responsibility onto individual consumers, while the structural conditions producing plastic overproduction remain untouched — in line with the 'green economy' paradigm.

The mystification operated on and across the data carries unequal consequences across nations. Weaker

and poorer countries disproportionately absorb the material and health costs of mismanaged plastic flows, while remaining peripheral to the governance arenas where recycling targets and reporting standards are defined. At the same time, the ever-changing nature of international relations continuously reshapes the global chain of plastic production and consumption. A just and effective global plastics regime must therefore go beyond technical recycling metrics, focussing instead on issues of producer accountability, transparent data governance and the redistribution of both burdens and decision-making power across the national hierarchies that structure the global plastic economy.

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Do Urban Policies Really Reduce Plastic Waste? Evidence and Limits from European Cities

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Keywords: plastic waste, urban policies, circular economy, European cities, sustainability - Associated conference sessions: 5

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Plastic pollution represents a major environmental challenge, (Geyer et al., 2017). At EU level, regulatory frameworks have expanded significantly, from the Single-Use Plastics Directive (European Commission, 2019) and the Circular Economy Action Plan (European Commission, 2020) to the recent Packaging Waste Regulation (EU) 2025/40. Cities, remain the arenas where these frameworks are translated into concrete interventions, where governance, infrastructures and everyday practices intersect (Geels, 2002). This study asks: *to what extent can urban policies reduce plastic waste, and under which conditions these reductions become measurable?*

To address this question, we analyse three European cities – Milan, Barcelona and Berlin – that have introduced policy mixes targeting single-use plastics over the last decade. We draw on municipal documents, national reports (ISPRA, 2025) and peer-reviewed literature, focusing on bans, deposit return systems (DRS), reuse infrastructures and economic incentives, in line with the EU circular economy strategy.

In **Milan**, the 2019 *Milano Plastic Free* campaign (Comune di Milano, 2019), and the 2021 sustainability criteria for events (Comune di Milano, 2021), integrated within the Air and Climate Plan (Comune di Milano, 2022), form a set of demand-side measures. According to ISPRA (2025), in 2024 Milan reached 63.3 % separate waste collection, while Italy exceeded for the first time the EU 50 % recycling target for plastic packaging (51.1 %).

In **Barcelona**, the *Compromís Barcelona Zero Plàstic* (Ajuntament de Barcelona, 2019), and the *Pla Residu Zero 2021-2027*, (Ajuntament de Barcelona, 2021), define a city-wide strategy. Since 2023, businesses reducing/eliminating single-use plastics receive a 10 % rebate on commercial waste collection price (Ajuntament de Barcelona, 2022), supported by national measures (Law 7/2022 and Royal Decree 1055/2022) including a tax of €0.45/kg on non-recycled plastic packaging, single-use plastic bans and bulk-sale obligations for retailers above 400 m² (BOE, 2022a, 2022b). However, the planned nationwide DRS is not yet operational.

In **Berlin**, action operates within a stronger national framework. Germany's DRS on single-use beverage containers (since 2003) achieves return rates above 98% (Picuno et al., 2025). The 2019 Packaging Act (*Verpackungsgesetz*), as amended in 2023, additionally requires food businesses to offer reusable packaging and accept consumer containers. However, a gap persists between awareness and actual reuse practices (Theobald et al., 2024).

These findings should be interpreted with caution, as differences in data collection methods and local contexts limit direct comparability. Reductions emerge from the interaction between regulatory tools, infrastructures and citizens' practices (Geels, 2002). The effectiveness of urban policies therefore depends less on individual measures and more on their integration within coordinated, multi-level governance frameworks.

Urban policies can significantly reduce plastic waste, but only when embedded in broader and coordinated strategies. This study highlights both the potential and limits of city-level interventions, pointing to the need for stronger cross-scale coordination.

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Plastic Transition: New Practices, Negotiation Processes and Resistances in Local Contexts of Circular Innovation

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Keywords: eco-social transition, circular economy, practice, governance, behavioural change.

Associated conference sessions: 5

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Since 2015, the Emilia-Romagna Region has funded the ATERSIR Fund for waste prevention and reduction (Regional Law 16/2015), with the aim of promoting circular economy principles as practices in support of the ecological transition. In 2025, 88 project proposals were submitted from across the region, mobilising a total of 2.2 million euros in funding.

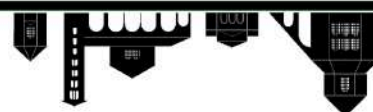
Against this backdrop, the Municipality of Castel Bolognese (RA) has embarked on a process of transformation of local public events and festivities, with the goal of making them zero-impact. Supported by the Fund, the first pilot project "Ecofeste-KIT" was launched in 2026, providing local associations with a kit of reusable materials - hard plastic cups and industrial cup-washing machines - to progressively replace the single-use compostable plastic cups currently employed at fairs and festivals endorsed by the Municipality, with the target of reducing their use by 75% in the first year and eliminating it entirely within three years.

Through semi-structured interviews and participant observation conducted with representatives of the associations involved, municipal officers, and citizens of Castel Bolognese, the research aims to investigate the processes through which new practices stabilise, spread or break down over the course of the project, attending both to the conditions that support their consolidation and to the resistances and negotiations that emerge within the local context. The Ecofeste-KIT case is thus read as a living laboratory in which to observe in real time the formation - or the failure to take root - of sustainable practices within a context of public sociality, contributing to the sociological debate on the effectiveness of infrastructural interventions as a lever for behavioural change at the community scale (Shove and Walker, 2010).

This work was supported by the Centro per i problemi della città e del territorio (CePCiT) of the University of Bologna and the Municipality of Castel Bolognese.

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Grest “Plastic Free”: a parish summer programme as a non-conventional channel for microplastics awareness

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Keywords: environmental education, science communication, community engagement, behavioural change.

Associated conference session: 5.

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The “Grest” (Summer Group) is a recreational summer programme for children aged 7 to 13, organised by many parishes with the support of teenage and young adult volunteers.

The proposal aims to combine Grest’s traditional educational approach with the theme of reducing plastic consumption, with the goal of raising awareness and encouraging small but concrete actions. It will be implemented at multiple levels—through lectures, workshops, games, and hands-on activities—and will target various groups: children, teenage counselors, parents, and adult volunteers. Every group is engaged in a way that is appropriate to age, role, and prior knowledge.

The programme consists of five stages, each tailored to a specific audience. The first step consists of presenting a well-founded proposal on the topic of microplastics to *parish leadership*, turning this moment into an initial formative opportunity. The proposal includes a brief introduction to the issue, highlighting its educational value also from a religious perspective, by connecting it to the care of Creation. Finally, some concrete actions are suggested for organizing the event: the use of reusable tableware, preference for tap water, reduction of packaging, and attention to the composition of clothing fabrics.

Adult volunteers (cooks, stewarding/cleaning staff) are therefore involved through an informal meeting — one that is accessible and practical rather than didactic — to discuss the motivations and actions underpinning the chosen approach.

Children’s activities (Monday to Friday) are playful and age-appropriate: weekly afternoon workshops with experiments, videos or quizzes; daily morning “slots” with short tips on good environmental practices; and team-based litter-picking in the neighbourhood. *Teenage animators* will receive dedicated training before the Grest begins, with the support of relevant professionals (an ecologist, an

educator, and a psychologist to help manage eco-anxiety in younger children). They also organise creative activities — such as theatre, poster-making, slogan-writing, music and video competitions — thereby encouraging greater engagement among young people on the subject.

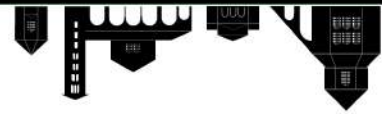
The *closing evening with parents* is designed to spark curiosity rather than deliver a lesson: a quiz competition between parents and children on environmental themes, with the children as favourites thanks to the programme completed, possibly followed by distribution of a leaflet with scientific references and further reading.

The evaluation of the event varies depending on the target audience. For children: a Likert scale with smiley faces at the end of each workshop; ongoing feedback with group leaders; the final quiz to assess the knowledge gained. For teenagers and adults: a short questionnaire on satisfaction, increased awareness and the potential impact on lifestyle.

This project aims to highlight the contribution that community-based local organisations can make to environmental education, whilst reaching people of all ages through personalised and participatory approaches

This work is the result of activities carried out during the ‘Advanced Course in Science Communication and Public Engagement’ at the University of Ferrara. The author is very grateful to the lecturers





Migrants, Ecomafia Processes and De-territorial transformation in Ragusa (Sicily)

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Keywords: migrants; rights; agriculture; plastics; crime

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The contribution analyses the spatial and social organization of the “transformed area of Ragusa” where foreign immigrants live and work. The objective is to return – with the support of statistical data, cartography and photography – on the socio- territorial characteristics of a context, where the transition from seasonality to intensive crops in greenhouses has not been configured as a transition to a new production of territoriality, with new formulations of the co- evolutionary relationship between human settlement and environment, but is the outcome of a socio- economic by its nature de - territorialized and, therefore, organized in an abstract space, homologated, random and artificial. This is a territory where the effects of an agriculture that has become increasingly industrialized and globalized are concentrated, feeding on a growing exploitation of migrant labour and the ecosystem, also at the hands of an organized crime that controls the management of plastics, agrochemicals and waste that these materials determine.



Figure 1. Socio-spatial organization of the “transformed area of Ragusa” in Sicily: “plasticized” landscape

Figure 2. Agricultural areas used for artificially irrigated crops



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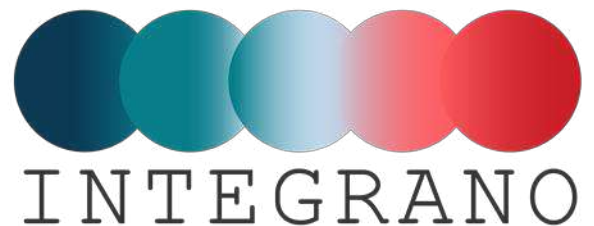


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