

MICROPLASTICdays

Beyond boundaries in microplastic research

3–5 February 2026

Faculty of Chemistry and Chemical Technology
Ljubljana, Slovenia



Book of abstracts

Ljubljana, 2026



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MICROPLASTICdays – Book of abstracts

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This book compiles the abstracts of invited presentations given during MICROPLASTICdays, conducted from 3–5 February 2026 at the Faculty of Chemistry and Chemical Technology, University of Ljubljana (UL FKKT), Slovenia. The abstracts are reproduced as submitted by the authors.

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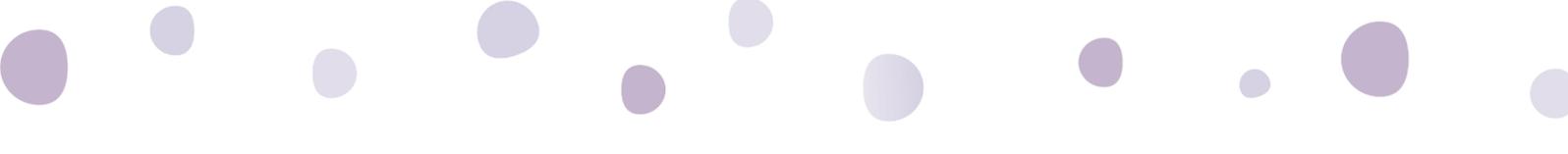


MICROPLASTIC*days* are dedicated to strengthening collaboration and advancing scientific excellence in microplastic research, metrology, and standardization. The event brings together experts from diverse disciplines to address current analytical challenges, methodological developments, and emerging research directions in the field.

Through seminars, hands-on training sessions, scientific presentations, and interactive discussions, participants gain comprehensive insights into the complex behavior, detection, and impact of microplastics. Particular attention is given to advanced analytical approaches and state-of-the-art instrumentation for microplastic identification and characterization. The event also provides opportunities to explore cutting-edge research equipment through sponsor-supported demonstrations, fostering direct exchange between researchers and technology providers.

Organized by a network of research projects, institutions, and leading experts, MICROPLASTIC*days* serve as a dynamic platform for scientists, industry representatives, policymakers, and other stakeholders to share knowledge, present innovations, and develop collaborative solutions.

More than a conference, MICROPLASTIC*days* represent a collective commitment to advancing methodological rigor, harmonization, and impactful research aimed at better understanding and mitigating microplastic pollution.



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MICROPLASTICdays

Beyond boundaries in microplastic research

3–5 February 2026

**Faculty of Chemistry and Chemical Technology
Ljubljana, Slovenia**



PROGRAMME



Environment Testing



This event is based upon work from COST Action PRIORITY-GA20101, supported by COST [European Cooperation in Science and Technology]. COST [European Cooperation in Science and Technology] is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

Tuesday, February 3, 2026

8:30-9:20	Registration		
9:20-9:35	Opening & Welcome		
9:35-9:45	Laura Rodrigez-Lorenzo INL, Portugal	Introduction of COST Action ICPLASTIC: ISO compatible, efficient and reproducible protocols/equipment for mICro-nanoPLASTIC detection through machine-learning	
Chairs: Thomas Meisel, Serena Ducoli			
9:45-10:20	Stefania Federici University of Brescia, Italy	<i>Opening lecture: Shaping the next generation of environmentally relevant microplastic test materials</i>	
10:20-11:35	Lyndsey Hendriks University of Vienna, Austria	Flow image analysis and single-particle ICP-TOFMS for comprehensive characterization of microplastics	Preparation & characterization
	Klaudia Krysiak-Smulek Adam Mickiewicz University, Poland	Obtaining nanoPET labelled with photon up-converting nanoparticles and its visualisation in biological materials	
	Florian Meier Postnova Analytics GmbH, Germany	Nano-sized polypropylene as a promising candidate reference material: Preparation, characterization and stability in complex matrices	
	Marcel Klotz Technical University of Munich, Germany	Toward high-throughput particle-by-particle micro- and nanoplastics analysis via fluorescence-guided O-PTIR characterization	
	Benedikt Hufnagl Hufnagl Chemometrics GmbH, Austria	From microplastics to microfibers – Modelling scattering and absorbance effects in μ FTIR spectra using machine learning	
	Jaromír Bačovský Delong Instruments, Czech Republic	High-contrast imaging and characterization of environmental-like microplastic & nanoplastic (eMNPs) by Low-Voltage Transmission Electron Microscope	
11:35-12:05	Coffee break and poster viewing		
Chairs: Stefania Federici, Jan Biskupič			
12:05-13:05	Maarten Roeffaers KU Leuven, Belgium	Smart chemistry for seeing the unseen: optical microplastic detection in complex biological matrices	Analytics
	Lukas Brunnbauer TU Wien, Austria	Revealing tire wear particles in zebrafish guts by LA-ICP-MS-based elemental fingerprinting and machine learning	
	Kirsten Siebers Utrecht University, Netherlands	Application of total reflection X-ray fluorescence spectroscopy for trace-level metal quantification in labelled nanoplastics	
	Tomáš Zikmund, CEITEC, Czech Republic	Tracking microplastics in zebrafish guts using micro-computed tomography	
	Andreas Kerstan Agilent Technologies, Inc., Germany	Fast und automated microplastics analysis in carbonated beverages by QCI based LDIR- A critical evaluation of spectral range selection and size detection limits	

13:05-13:20	Flash presentations		
	Serena Ducoli University of Brescia, Italy	Quantitative evaluation of true-to-life nanoplastics using UV-visible spectroscopy and comparative analytical techniques	
	Jan Biskupič Masaryk University, Czech Republic	Unveiling microplastics distribution in biological tissues: A combined μ CT and LA-ICP-MS strategy for spatial distribution and chemical characterization	
	Martina Potočnik University of Ljubljana, Slovenia	In search of the detection limit for PET microplastics using the TGA-IST16-GC-MS measurement system	
	Pavel Chaloupsky Masaryk University, Mendel University in Brno, Czech Republic	Laser-Induced Breakdown Spectroscopy imaging of plastics from cave environment	
	Lars Mester attocube systems GmbH, Germany	Nano-IR spectroscopy for nanoplastics identification down to 10 nm particle size	
13:20-14:30	Lunch break and poster viewing		
Chairs: Helena Oliveira, Tatjana Mijošek Pavin			
14:30-15:00	Anita Jemec Kokalj University of Ljubljana, Slovenia	Keynote lecture: Effects of agricultural plastics on soil	
15:00-15:50	Jiří Kučerík Mendel University in Brno, Czech Republic	Microplastics of biodegradable polyhydroxyalkanoates: impact on plant growth and soil health	Impacts
	María Dolores Hernando Guil The Spanish National Research Council, Spain	Uncovering metabolomic dysregulation in plants caused by exposure to nano - and microplastics (NMPs)	
	Gergely Horváth Eötvös Loránd University, Hungary	Dietary microplastic uptake increases risk-taking behaviour in a widespread decomposer, the common pill bug (<i>Armadillidium vulgare</i>)	
	Michaela Kuchynka Masaryk University, Czech Republic	Exploring the application of metal-doped nanoplastics in environmental studies: Uptake and distribution in duckweed <i>Lemna minor</i>	
15.50-16.20	Coffee break and poster viewing		

Chairs: Anita Jemec Kokalj, Bram Dumoulin			
16:20-17:45	Maysan Nashashibi Leibniz Institute of freshwater ecology and inland fisheries, Germany	When pollutants interact: triclosan reverses nanoplastic-induced parasite infection in <i>Daphnia galeata</i>	Impacts
	Amadeo Fernández-Alba University of Almería, Spain	Evaluating microplastic contamination in endangered wild species: Analytical method development for detection in lung tissues	
	Helena Oliveira University of Aveiro, Portugal	Toxicity of polyethylene terephthalate micro- and nanoplastics and their degradation products in liver and intestinal cells	
	Pablo Jiménez López University of Almería, Spain	Polystyrene nanoplastics oral exposure promotes insulin resistance in mice	
	Lucio Litti University of Padova, Italy	Unravelling the interaction of environmental microplastics with human reproductive fluids	
	Verónica Bastos University of Aveiro, Portugal	A toxicological shift: comparing the cytotoxicity of PE, bioplastics and fungal degradation by-products	
	Giulia Nannini University of Florence, Italy	Disruption of the microbiota-immune axis by mixed nano- and microplastic exposure in C57BL/6J mice	
17:45-18:00	Flash presentations		
	Teja Pelko University of Ljubljana, Slovenia	Composted microplastics from conventional and biodegradable plastic bags induce a stress response in sunflowers	
	Ludmiła Polechońska University of Wrocław, Poland	Co-exposure of microplastics and trace metals – does it affect bioadhesion of microplastics, growth, and elemental composition of aquatic macrophyte?	
	Verdiana Vellani University of Trieste & CoNISMa, Italy	Ecotoxicological responses and intake of marine and freshwater model organisms to micro- and nanoplastics (MNPs) with different surface functionalizations	
	Kevin Ugwu Roskilde University, Denmark	Impacts of polystyrene and tire wear nanoplastics on early development and feeding of blue mussel (<i>Mytilus edulis</i>) larvae	

Wednesday, February 4, 2026

8:30-9:00	Registration	
Chairs: Gilberto Binda, Barbara Klun		
9:00-9:30	Andy Booth SINTEF Ocean, Norway	Keynote lecture: Plastic additive chemicals: A key factor in assessing micro- and nanoplastic Risks
9:30-10:45	Ula Rozman University of Ljubljana, Slovenia	Biofouling of microplastics surfaces alters microplastic–nutrient interactions in aquatic environments
	Bence Prikler Hungarian University of Agriculture and Life Sciences, Hungary	Biofilm formation on common plastics: influence of polymer type and particle size
	Ludovica Botta University of Insubria, Italy	Understanding the interactions between plastics and metals: Plastic-related governing factors and metal leaching behavior
	Adriaan Duijndam Utrecht University, Netherlands	The Influence of surface chemistry on the degradation of polystyrene nanoplastics
	Maja Vujić University of Novi Sad, Republic of Serbia	Comparative adsorption study of 4-methylbenzylidene camphor on true-to-life microplastic particles derived from post-consumer polymers in water
	Tommaso Grande University of Insubria, Italy	Evaluating the role of manufacturing and post-processing in the release of metal-containing additives from polylactic acid products
10:45-11:15	Coffee break and poster viewing	

Interactions

Chairs: Benedikt Hufnagl, Mario Rigo			
11:15-12:15	Daura Vega-Moreno University of Las Palmas de Gran Canaria, Spain	Heterogeneous distribution of small MPs in the water column: a perfect hiding place for plastic	Monitoring
	Erica Sparaventi National Institute of Biology, Slovenia	Environmental aged plastic characterization	
	Irene Mandrini IRTA - Institute of Agrifood Research and Technology, Spain	Towards standardized methods to assess microplastic pollution and its links to soil properties and management in Mediterranean agricultural soils	
	Ieva Uogintė Center for physical sciences and technology, Lithuania	Assessment of indoor airborne microplastics in a high school environment	
	Raffaele Bruschi University of Trieste, Italy	Microplastics in pristine karst caves of the Timavo system: baseline contamination and methodological insights from inaccessible environments	
12:15-12:30	Flash presentations		
	Pia Leban Jožef Stefan Institute, Department of Environmental Sciences, Slovenia	Development of an extraction protocol for nanoplastics in agricultural soils	
	Sania Kanwal Memon University of Padova, Italy	Microplastic detection using portable Raman spectroscopy: A review of developments in environmental monitoring	
	Francesca Cherchi University of Insubria, Italy	From marine to freshwater sediments: the role of microplastic size in shaping ecosystem functioning	
	Francisca Espincho CIIMAR, Portugal	Degradation of submerged fishing gear and their MP release potential: comparative data from a mesocosm and <i>in situ</i> experiment	
	Anett Välimets National Institute of Chemical Physics and Biophysics, Estonia	Monitoring and quantification of microplastics emissions and measures to decrease microplastics pollution from Finnish and Estonian WWTPs into the Baltic Sea – project “Balt-Plast-Free”	
12:30-14:00	Lunch break and poster viewing		

Chairs: Andy Booth, Maja Vujić			
14:00-15:30	Gabor Bordos Eurofins Environment Testing, Hungary	Microplastic sampling and analysis in the MicroDrink and PlasticDustCloud projects	Monitoring
	Laurens Mandemaker Utrecht University, Netherlands	Scanning probe microscopy methods to characterize nanoplastics from baby bottles	
	Ana Molina Rodríguez University of Las Palmas de Gran Canaria, Spain	Degradation and deep distribution of small microplastics for polyethylene and polypropylene in the Canary Islands waters	
	Morena Gaudino Atlantic Technological University, Ireland	Investigating the impact of extreme weather events on microplastic pollution in intertidal sediments	
	Tamara Bizjak Institute for Water of the Republic of Slovenia, Slovenia	Quantification of microplastic contamination in Sava River (Slovenia): Lessons learned from Aquatic plastic project	
	Valentina Balestra University of Turin, Italy	Microplastic pollution in livestock sector	
	Urban Novak Optik Instruments, Slovenia	Introduction of Bruker solutions for microplastic analysis	
15.30-16.00	Coffee break and poster viewing		

Chairs: Kristian Syberg, Katja Turk			
16:00-17:25	Andrea Barrientos Riosalido Rovira i Virgili University, Spain	Microplastics in commercial beverages: influence of packaging material	Monitoring & Effects
	María Jesús Martínez Bueno University of Almería, Spain	First study on the potential impact of plastic greenhouse environments on airborne microplastics presence	
	Zeynep Sena Ozkan Istanbul Technical University, Türkiye	Investigation of microfibers and microplastics in process water from spunlace nonwoven production	
	Tanja Kobal Marine Biology Station Piran, Slovenia	Microplastics as vectors for TBT transfer in mussel <i>Mytilus galloprovincialis</i>	
	Fernanda Rosário University of Aveiro, Portugal	A dangerous cocktail?! Assessing the eco-toxicological threats of nano/microplastics mixed with pharmaceuticals	
	Sabrina M. Rodrigues CIIMAR-UP, Portugal	Fishing gear as an emergent pollutant: microplastic release and contaminant adsorption	
	Marina Vargas Ferraz University of Las Palmas de Gran Canaria, Spain	Evaluating the impact of northwest African upwelling-derived marine litter on animal entanglement in the Canary Islands	
17:25 – 17:35	Flash presentations		
	Barbara Klun University of Ljubljana, Slovenia	Biofilm formation on microplastics shaped by environmental factors and polymer type	
	Lerato Mothoa Hungarian University of Agriculture and Life Sciences, Hungary	Characterization of culturable bacterial communities on common polymers in wastewater treatment environments	
	Sinem Hazal Akyıldız Polytechnic University of Turin, Italy	Clean clothes, dirty oceans: Microplastic fiber emissions from synthetic fabrics	
	Tatjana Mijošek Pavin Ruđer Bošković Institute, Croatia	From seawater to mussels: an integrated study of microplastics and oxidative stress responses	
	Bram Dumoulin KU Leuven, Belgium	Beyond the visible: (bio)chemical methods to reveal nanoplastics in blood	

Thursday, February 5, 2026

8:30-9:00	Registration	
Chairs: Aleksandra Tubić, Vaibhav Budhiraja		
9:00-9:30	Kristian Syberg Roskilde University, Denmark	Keynote lecture: The future of plastic pollution in the light of the ongoing plastic treaty negotiations
9:30-10:45	Andreja Palatinus National Institute of Chemistry & Andreja Palatinus s.p., Slovenia	Clean Coast (<i>Čista obala</i>): 15 years of coastal clean-up and citizen science on marine litter in Slovenia
	Yemi Ayankoya Ayankunle National Institute of Chemical Physics and Biophysics, Estonia	Towards reduced microplastics discharge from wastewater treatment plants
	Jan Puhar University of Maribor, Slovenia	Pilot testing of cascade treatment system for retention and elimination of micro- and nanoplastics from wastewater treatment plant effluent
	Ugne Gliaudelyte-Ulrike Kaunas University of Technology, Lithuania	Tuning nitrogen plasma treatments to reduce microplastic release from synthetic textile materials
	Belén Carboneras Contreras Captoplastic SL, Spain	Are wastewater treatment plants efficient at removing microplastics? – A novel analytical technique to analyze microplastics in complex matrices
	Kristina Kralj Czech University of Life Sciences, Czech Republic	Arbuscular mycorrhizal fungi improve treatment performance and vegetative resilience in constructed wetlands exposed to microplastics
10:45-11:15	Coffee break and poster viewing	

Solutions

Chairs: Gabriela Kalčíková, Kevin Ugwu			
11:15-11:50	Vaibhav Budhiraja National Institute of Chemistry, Slovenia	Remediation of microplastic pollution by plasma treatment	Solutions
	Sonata Pleskyté Center for Physical Sciences and Technology, Lithuania	Influence of physical properties on the photocatalytic degradation of LDPE mulch films	
	Akhila Rahul University of Strathclyde, United Kingdom	Microplastics: From detection to degradation	
11:50-12:05	Flash presentations		
	Sichen Song Utrecht University, Netherlands	Tailored synthesis of polyvinyl chloride nanoplastics by nanoprecipitation for risk assessment	
	Harshit Sahai University of Almería, Spain	Tri-analytical investigation of UV-induced degradation in agricultural plastics: toward Safe-and-Sustainable-by-Design polymers	
	Mario Rigo University of Brescia	Vintage by design: A UV-hydrolysis aging protocol for environmentally realistic PET microplastics	
	Federica Rotta University of Pavia, Italy	Microplastics in motion: sediment traps reveal vertical fluxes in a deep holomictic lake	
	Raghuvir Raghav Das Wuppertal Institute for Climate, Environment and Energy, Germany	A review and analysis of market based innovative financing instruments to finance plastic waste management	
12:05 – 12:30	Closing ceremony		
12:30-14:00	Break		
14:00-17:30	Workshop for young researchers <i>Measurement uncertainties in microplastic laboratory research: Towards reliable and comparable results</i>		

Poster presentations

1	Enrico Stuani University of Brescia, Italy	True-to-life microplastics: Bridging laboratory and environmental relevance
2	Mark Starin University of Ljubljana, Slovenia	Exploring the potential of magnetically modified microplastics
3	Ajay Khairnar Technical University of Leoben, Austria	Synthesis of standardized core-shell nanoplastics for environmental and toxicological research
4	Anamaria Couți Babeş-Bolyai University, Romania	The production of environmental micro- and nanoplastics from marine-aged plastics
5	Matilda Porro Italian Institute of Technology, Italy	Analysis of production and characterization of PLA micro and nanoplastics using ball-milling technique
6	Sichen Song Utrecht University, Netherlands	Tailored synthesis of polyvinyl chloride nanoplastics by nanoprecipitation for risk assessment
7	Mario Rigo University of Brescia	Vintage by design: A UV-hydrolysis aging protocol for environmentally realistic PET microplastics
8	Silvia Lupato, Polytechnic University of Turin, Italy	Microplastic fibers detection in laundry wastewater: An aerial quantification based method
9	Emília Laura Dzsudzsák Hungarian University of Agriculture and Life Sciences, Hungary	Mapping of sewage-derived, antibiotic-resistant microbes potentially involved in microplastic colonization in a Hungarian surface water body
10	Girija Prasad Central Institute of Petrochemical Engineering and Technology, India	Seasonal dynamics and ecological risk evaluation of microplastics in the Cauvery River, Tamil Nadu, India
11	Giorgia Dassie University of Brescia, Italy	Microplastics release in snow from UHMWPE ski bases: Tribometer simulation and spectroscopic analysis
12	Eliška Kameníková Brno University of Technology, Czech Republic	Detection of PET microplastics in soils using thermoanalytical methods
13	Christoph Kappacher University Innsbruck, Austria	A new approach to QA/QC in particle-based microplastic analysis using deuterated polymers
14	Jakob Lauß University of Innsbruck, Austria	Assessing recovery and method performance for microplastic detection in drinking water using custom-made spike particles

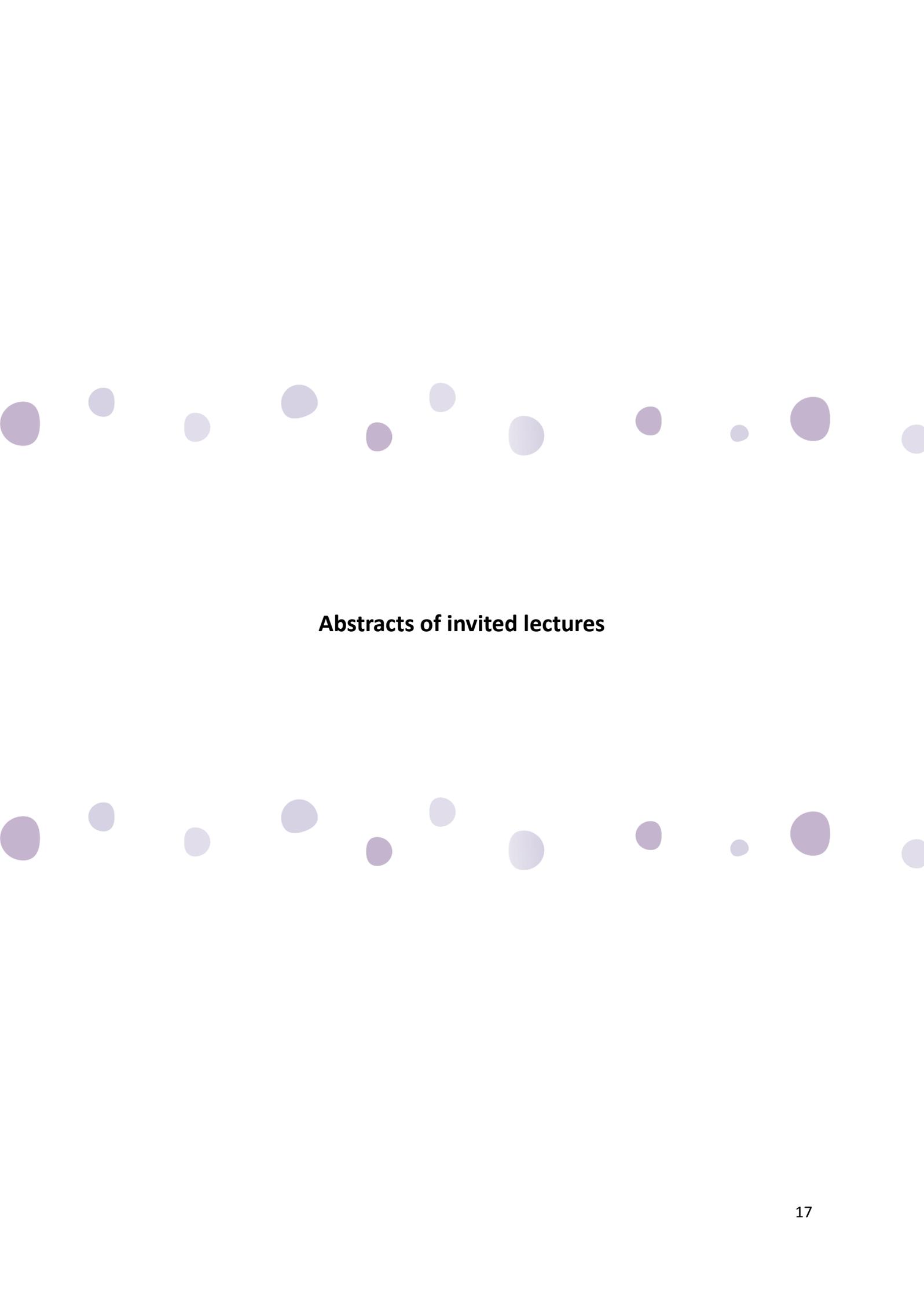
15	Karuna Singh National Institute of Technology Delhi, India	Interpreting microplastic pollution as a reflection of water quality degradation in highly sediment urban river
16	Ioana Cardan Babeş-Bolyai University, Romania	SERS detection of environmental nanoplastics by using customized plasmonic nanostructured substrates
17	María Jesús Martínez Bueno University of Almería, Spain	Developed and optimization of an analytical protocol for quantifying fine microplastics in greenhouse agricultural soils
18	Ion Nesterovschi Babeş-Bolyai University, Romania	Identification of micro- and nanoplastics in Adriatic aquaculture waters using Raman and SERS spectroscopy
19	Florian Meier Postnova Analytics GmbH, Germany	MikAlp - Analysis of micro- and nanoplastics in complex water matrices: knowledge and analytical method transfer from academia to industry
20	Piotr Zielinski University of Białystok, Poland	Microplastics in Polish freshwater ecosystems: Present insights and research challenges
21	Sania Kanwal Memon University of Padova, Italy	Microplastic detection using portable Raman spectroscopy: A review of developments in environmental monitoring
22	Sinem Hazal Akyıldız Polytechnic University of Turin, Italy	Clean clothes, dirty oceans: Microplastic fiber emissions from synthetic fabrics
23	Isabel Juengling Technical University of Munich, Germany	Evaluating filter materials and device parameters for automated microplastic quantification with Raman microspectroscopy
24	Natalia Ivleva Technical University of Munich, Germany	Challenges, advanced methods and perspectives in physico-chemical characterization of nanoplastics
25	Arianna Fornasari University of Bologna, Italy	Optimized digestion of human tissues for efficient microplastic analysis by μ Raman
26	Milica Popović Institute of Physics Belgrade, Republic of Serbia	Third harmonic generation imaging: A novel, label-free method for microplastic detection
27	Trijn Vervoort KU Leuven, Belgium	Detection and quantification of microplastics in milk using fluorescence microscopy
28	Edit Kaszab Hungarian University of Agriculture and Life Sciences, Hungary	Analyzing microplastics and heavy metals in Hungarian sewage sludge samples and their effect on opportunistic pathogen <i>Pseudomonas aeruginosa</i>
29	Lars Mester attocube systems GmbH, Germany	Nano-IR spectroscopy for nanoplastics identification down to 10 nm particle size

30	Tatjana Mijošek Pavin Ruđer Bošković Institute, Croatia	From seawater to mussels: an integrated study of microplastics and oxidative stress responses
31	Serena Ducoli University of Brescia, Italy	Quantitative evaluation of true-to-life nanoplastics using UV-visible spectroscopy and comparative analytical techniques
32	Martina Potočnik University of Ljubljana, Slovenia	In search of the detection limit for PET microplastics using the TGA-IST16-GC-MS measurement system
33	Jan Biskupič Masaryk University, Czech Republic	Unveiling Microplastics Distribution in Biological Tissues: A Combined μ CT and LA-ICP-MS Strategy for Spatial Distribution and Chemical Characterization
34	Harshit Sahai University of Almería, Spain	Tri-analytical investigation of UV-induced degradation in agricultural plastics: toward Safe-and-Sustainable-by-Design polymers
35	Pia Leban Jožef Stefan Institute, Slovenia	Development of an extraction protocol for nanoplastics in agricultural soils
36	Pavel Chaloupsky Masaryk University & Mendel University in Brno, Czech Republic	Laser-Induced Breakdown Spectroscopy imaging of plastics from cave environment
37	Anett Välimets National Institute of Chemical Physics and Biophysics, Estonia	Monitoring and quantification of microplastics emissions and measures to decrease microplastics pollution from Finnish and Estonian WWTPs into the Baltic Sea – project “Balt-Plast-Free”
38	Petra Procházková Mendel University in Brno, Czech Republic	Impact of biodegradable microplastics on soil quality
39	Nina Češnovar University of Ljubljana, Slovenia	Soil microbial diversity shifts in microplastic polluted compost
40	Nina Češnovar University of Ljubljana, Slovenia	Exposure of microbial consortia to microplastics
41	Magdalena Podbielska University of Rzeszow, Poland	Combined effects of glyphosate and polyethylene microplastics on <i>Chlorella vulgaris</i> : Insights into algal responses and environmental risks
42	Gilberto Binda Insubria University, Italy	Introducing AWARE project: the key role of plastic in mediating ecosystem fluxes at the sediment-water interface
43	Andraž Dolar University of Ljubljana, Slovenia	Sex-dependent variations in the immune status of the terrestrial isopod <i>Porcellio laevis</i> (Crustacea, Isopoda) as a response to microplastic exposure in soil
44	Jure Mravlje University of Ljubljana, Slovenia	Effect of microplastic leachates on growth and selected physiological parameters of common buckwheat (<i>Fagopyrum esculentum Moench.</i>) in hydroponic experiment

45	Megan Gutman Queen Mary University of London, United Kingdom	Oxo-biodegradable low-density polyethylene: The impact of artificial weathering parameters on abiotic degradation
46	Małgorzata Dambiec University of Wrocław, Poland	Comparative effects of different types of microplastics on <i>Salvinia auriculata</i>
47	Urša Košak University of Ljubljana, Slovenia	Effect of biodegradable and conventional microplastics on freshwater microcosm
48	Zoran Stojanovic Institute of Technical Sciences of SASA, Republic of Serbia	RAG-Augmented information extraction framework for enhanced literature analysis in microplastic toxicology studies
49	Marina Auer University of Brescia, Italy	Influence of extraction conditions on microplastic detection and polymer integrity in biological matrices
50	Konstantin Malafeev Tampere University, Finland	Formation and cytotoxicity of microplastics from biodegradable materials and biocomposites
51	Mariana Lamas REQUIMTE/LAQV-ISEP, Portugal	Human occupational exposure to microplastics
52	Dávid Herczeg Eötvös Loránd University, Hungary	Microplastics impair behavioural defences against predators in amphibian larvae
53	Ivana Guševac Stojanović VINČA Institute of Nuclear Sciences, Republic of Serbia	Acute, size-dependent effects of oral microplastic exposure on liver and lipid biochemical markers in rats
54	Janja Novak University of Ljubljana, Slovenia	Investigation of interactions of water-soluble acrylic acid-based polymers with activated sludge
55	Anja Klančnik University of Ljubljana, Slovenia	Microplastics in the food chain – pathways of entry and awareness
56	Tina Šaula University of Ljubljana, Slovenia	<i>Pseudomonas</i> spp. biofilms enable <i>Campylobacter jejuni</i> survival on microplastics
57	Balázs Göbölös Hungarian University of Agriculture and Life Sciences, Hungary	Ecotoxicological study of an important industrial material adipic acid and its symmetrical esters and their mixtures
58	Manuela Piccardo University of Trieste, Italy	Index-based environmental risk assessment of micro- and nanoplastics: Handbook for conscious, accurate, and standardized use

59	Mariana Lamas REQUIMTE/LAQV-ISEP, Portugal	Exploring the degradation of microplastics after gastrointestinal digestion
60	Arianna Varrani Polish Academy of Sciences, Poland	Microplastics enhanced mobility on natural beds: the combined roles of abundance and bed roughness
61	Malgorzata Kus-Liśkiewicz University of Rzeszów, Poland	Airborne microplastic in the inhaled atmosphere. Cytotoxicity assessment of air pollution particles
62	Bram Dumoulin KU Leuven, Belgium	Beyond the visible: (bio)chemical methods to reveal nanoplastics in blood
63	Leonardo Barlucchi University of Pisa, Italy	Photo-oxidative aging and leaching behavior of sustainable plastics in artificial seawater
64	Jakub Jurík Slovak University of Technology, Slovakia	Removal of amoxicillin by ozone in the presence of microplastics
65	Primož Treven Univerza v Ljubljani, Slovenija	Production and characterization of microplastics from commonly used infant products and applicability for biofilm assessment
66	Teja Pelko University of Ljubljana, Slovenia	Composted microplastics from conventional and biodegradable plastic bags induce a stress response in sunflowers
67	Francesca Cherchi University of Insubria, Italy	From marine to freshwater sediments: the role of microplastic size in shaping ecosystem functioning
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72	Barbara Klun University of Ljubljana, Slovenia	Biofilm formation on microplastics shaped by environmental factors and polymer type
73	Ludmiła Polechońska University of Wrocław, Poland	Co-exposure of microplastics and trace metals – does it affect bioadhesion of microplastics, growth, and elemental composition of aquatic macrophyte?

74	Kevin Ugwu Roskilde University, Denmark	Impacts of polystyrene and tire wear nanoplastics on early development and feeding of blue mussel (<i>Mytilus edulis</i>) larvae
75	Raghuvir Raghav Das Wuppertal Institute for Climate, Environment and Energy, Germany	A review and analysis of market based innovative financing instruments to finance plastic waste management
76	Paula Przygoda-Kuś Wrocław University of Environmental and Life Sciences, Poland	Discovery of <i>Serratia</i> and <i>Pseudomonas</i> strains with polyethylene-degrading potential
77	Katja Turk Slovenian National Building and Civil Engineering Institute, Slovenia	Microplastics in construction and build environment: From environmental pollution to circular opportunities
78	Maximilian Lackner go!PHA, Netherlands	Poly(hydroxyalkanoates) (PHA) as versatile platform against persistent micro-and nanoplastics
79	Maria Wierzbicka University of Warsaw, Poland	PET-derived carbon as a potential selective factor for <i>Bacillus cereus</i> in landfill bottle-interior microhabitats
80	Thomas Meisel Technical University of Leoben, Austria	Austrian Micro- and Nanoplastic Research (AMINAR) - a new platform



Abstracts of invited lectures

Introduction of COST Action ICPLASTIC - ISO COMPATIBLE, EFFICIENT AND REPRODUCIBLE PROTOCOLS/EQUIPMENT FOR MICRO-NANOPLASTIC DETECTION THROUGH MACHINE-LEARNING

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ICPLASTIC is an ambitious research network with a transformative goal: to develop efficient, reproducible protocols and equipment for micro- and nanoplastic sampling, sample preparation, and analysis, to both support the application of ISO standards and water quality legislation and to close knowledge gaps in risk analysis and occurrence.

The main aim of the Action is to develop a suitable formulation of efficient/reproducible protocols and equipment for micro- and nanoplastic sampling, sample preparation, and analysis to support the application of ISO standards and all water quality legislation, and close knowledge gaps in risk analysis through their enablement of improved toxicological/environmental studies.

Acknowledgments: COST Action CA23131 (ICPLASTIC - <http://www.icplastic.eu/>), supported by COST (European Cooperation in Science and Technology).

Shaping the next generation of environmentally relevant microplastic test materials

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Plastic pollution remains a major environmental concern, with micro- and nanoplastics emerging as key contributors due to their widespread presence and potential risks to ecosystems and human health. These plastic fragments often result from the degradation of larger plastic debris, and understanding their properties and behaviour is critical for assessing their environmental impact. However, despite recent progress in the preparation of test materials, the lack of harmonization and comparability among studies continues to hinder reliable assessment of environmentally relevant micro- and nanoplastics.

This contribution focuses on strategies and scientific approaches for developing micro- and nanoplastic test materials with high environmental relevance. It discusses how the preparation process, including polymer selection, fragmentation or ageing methods, can strongly influence the resulting particle morphology, chemistry, and reactivity. Particular attention is given to reproducing features observed in naturally aged plastics, such as oxidation, changes in crystallinity, and altered surface charge, which affect interfacial phenomena, such as aggregation, biofilm formation, and interactions with pollutants or biological systems.

By linking material design to environmental processes, this work highlights the importance of harmonised preparation protocols that bridge the gap between pristine laboratory materials and complex real-world particles. Examples from recent collaborative studies show how controlled weathering, mechanical wear, and photo-oxidation can be combined to produce materials that are both reproducible and environmentally realistic.

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Effects of agricultural plastics on soil

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Agricultural plastics, such as mulching films, have proven beneficial for increasing crop yields while reducing resource use, leading to a significant rise in their application over recent decades. However, their degradation and fragmentation result in microplastics (MPs) accumulating in agricultural soils, where their impact remains largely unknown. This lecture will present the latest findings on the effects of MPs from various mulching films on terrestrial organisms—including plants, microbes, and invertebrates—studied within the Horizon 2020 project PAPHILLONS. The research examined MP effects on soil through different experimental setups: single-species laboratory tests, mesocosm experiments, and real field trials. Additionally, results on MP presence in agricultural fields across Europe (Finland, Germany, and Spain) will be discussed. A survey of agricultural plastic (AP) usage and market trends shows that AP use increases from northern to southern Europe, with the highest usage recorded in Spain and southern Italy. Correspondingly, MP concentrations were also highest in these regions. Surprisingly, significant air deposition of MPs was detected even at control sites that had never been treated with plastic. Single-species toxicity tests were conducted on nine soil invertebrate species. Overall, MPs did not affect survival in a dose-dependent manner, even at the highest tested concentration of 5% (w/w dry soil). Sublethal effects were not consistently observed at this concentration, but some were detected, including reduced growth, oxidative stress in earthworms, impaired colony founding in ants, and altered immune responses in terrestrial crustaceans. Beyond direct impacts on invertebrates, MPs caused notable changes in soil properties such as water-holding capacity and pH. In mesocosm experiments, earthworm reproduction was negatively affected, and microbial communities shifted. Field trials revealed that barley plants exposed to MPs exhibited physiological stress indicators, while soil microbial composition changed and activity declined. Altogether, these findings indicate that agricultural MPs can significantly alter soil functions at high concentrations.

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Plastic additive chemicals: a key factor in assessing micro- and nanoplastic risks

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Micro- and nanoplastics (MNPs) are widespread environmental contaminants with growing evidence of biological toxicity. While size, shape, and polymer type have traditionally dominated hazard discussions, plastic additive chemicals are increasingly recognized as key drivers of MNP toxicity. Additives such as plasticizers, stabilizers, flame retardants, and colorants are intentionally added during manufacturing but are not chemically bound to the polymer, enabling their release into surrounding media, including water and biological fluids. The role of additives is complex, especially considering over 16,000 different chemicals are in use globally. These vary significantly by polymer type and individual consumer product, and many lack comprehensive toxicological data. Additionally, non-intentionally added substances (NIAS), such as production chemicals and degradation by-products, also contribute to the chemical profile and potential toxicity of MNPs. The leaching of these substances is influenced by environmental conditions and particle surface area, which is particularly relevant for nanoplastics. Despite these concerns, most MNP hazard assessments rely on poorly characterized or additive-free test materials, limiting ecological and regulatory relevance. There is a critical need for test and reference materials that reflect real-world plastic products, both chemically and physically. Car tyres exemplify the issue: composed of rubber and a large number of additives, their leachates are known to be toxic. Understanding whether observed toxicity originates from the particles, the leached chemicals, or both is crucial. Therefore, standard methods to separate particle and chemical toxicity—such as leachate testing or chemical extraction—must be implemented in hazard assessment. Without such approaches, the true drivers of observed toxicity remain unclear. Chemical additives and NIAS are central to the hazard profile of MNPs. Future research and regulation must incorporate additive chemistry to provide accurate environmental and health risk assessments and inform effective mitigation strategies.

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The future of plastic pollution in the light of the ongoing plastic treaty negotiations

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Given the persistent challenges in achieving consensus during international negotiations for a global plastic treaty, coupled with the projected increase in plastic production, it is unlikely that plastic pollution will decline in the foreseeable future. This trajectory raises critical questions: What are the implications of continuing along this path? What interventions are necessary to reverse this trend? And what role should the scientific community assume in addressing these issues?

This presentation aims to reflect on these questions by drawing on insights from participation in global plastic treaty negotiations and more than a decade of interdisciplinary research in plastic pollution. Specifically, it will explore (i) the underlying reasons for the persistent challenges in managing plastic pollution, (ii) the environmental and human health implications of this pollution, and (iii) potential strategies and solutions to mitigate the problem.



Abstracts of oral presentations



Flow image analysis and single-particle ICP-TOFMS for comprehensive characterization of microplastics

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Plastic pollution is a global environmental concern, and micro- and nanoplastics are now widespread in marine, freshwater, and atmospheric systems. Accurate characterization of their size, morphology, and composition is essential to understand their sources and potential impacts. However, current analytical approaches struggle to capture the complexity and heterogeneity of real-world plastic debris. There is a growing need for high-throughput tools that can provide reliable, multi-parameter data on individual particles.

Here, we combine single-particle inductively coupled plasma time-of-flight mass spectrometry (sp-ICP-TOFMS) with high throughput flow image analysis (FIA) to analyze both polymer standards and microplastics cryo-milled from ocean-weathered plastics. FIA provides particle size distributions, particle number concentrations (PNC), and morphological parameters such as shape and aspect ratio, while sp-ICP-TOFMS delivers elemental composition (carbon and metal additive content), particle mass, and PNC. Conventional sp-ICP-MS assumes a spherical geometry for size determination, an assumption which does not hold for irregular cryo-milled or real-life microplastics. Traditionally, morphology verification requires electron microscopy (SEM/TEM), which is accurate but time- and resource-intensive. Here, FIA offers a rapid and effective alternative for assessing morphology alongside sp-ICP-TOFMS analysis. Integrating both methods allows cross-validation of particle size and concentration data and supports more accurate interpretation of sp-ICP-TOFMS results for non-spherical plastics. This combined approach provides a practical workflow for comprehensive microplastic characterization and represents a promising analytical framework for advancing quantitative and morphological assessments in environmental plastics research.

Obtaining nanoPET labelled with photon up-converting nanoparticles and its visualisation in biological materials

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Poly(ethylene terephthalate) (PET) is one of the most commonly used plastics. Many daily-use objects, such as bottles, food containers, and clothing, contain PET as a main component. As a result of atmospheric and mechanical factors, they crumble, forming micro- and nanoplastics. These tiny plastic fragments end up in the environment, where microorganisms can absorb them. Our research aims to visualise nanoPET in biological materials. The challenge of this task lies in the chemical similarity between the tissues of living organisms and plastic – they are both organic compounds, which makes it challenging to visualise plastic in biological material using traditional analytical methods. To address this, we use upconverting nanoparticles (UCNPs). They have a unique property: when exposed to infrared radiation, they emit green light. Biological tissues do not exhibit this feature, which allows us to distinguish nanoplastics from biological materials. We have developed a method for obtaining UCNP-labelled nanoPET. It involves dissolving PET in an organic solvent, mixing it with UCNPs, and precipitating the aqueous colloid. DLS, AFM, TEM, and FTIR analysis confirmed the method's effectiveness. We then conducted ecotoxicity tests on environmental bacteria and freshwater microorganisms. After the tests, we imaged labelled PET in the organisms using a fluorescence microscope and an up-conversion plate reader. These techniques allowed us to determine the location of nanoPET accumulation in biological materials.

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Nano-sized polypropylene as a promising candidate reference material: preparation, characterization and stability in complex matrices

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The lack of nanoplastic (NPs) reference materials capable of mimicking real-world scenarios is currently hampering the development of validated extraction techniques from complex matrices, the development of analytical approaches for robust identification and quantification, and the ability to use environmentally relevant test materials in (eco)toxicity testing and hazard assessment

Here, we present a strategy towards the development of a potential NP reference material based on nano-sized polypropylene particles (nanoPP) developed within the EURAMET-funded PlasticTrace project (<https://plastictrace.eu/>). The strategy includes the preparation, the physicochemical characterization and the stability assessment of nanoPP in suspension both in its pristine state, but also when spiked into complex matrices like mineral water and milk.

NanoPP was produced reproducibly in a top-down approach by crushing in acetone with an UltraTurrax, filtering and change of solvent to MilliQ water. The prepared nanoPP material was subjected to a comprehensive physicochemical characterization including e.g., DLS, PTA and AF4-MALS for particle size distribution assessment, PTA and SEM for particle number concentration determination, SEM and AFM for shape analysis and pyrolysis GC-MS for chemical identification. Performed studies showed that the prepared nanoPP material is irregularly shaped and highly polydisperse with a particle size of around 180 nm (e.g., $D_{h,z-ave}$ from DLS) and a particle size distribution from around 15 nm up to 135 nm (radius of gyration R_g from AF4-MALS).

Storage stability studies using DLS, PTA and AF4-MALS revealed nanoPP in aqueous suspension to be stable for at least 22 months with respect to particle size distribution and number concentration rendering it a promising NP candidate reference material. However, conducted spiking experiments in mineral water and milk showed a time-dependent agglomeration of nanoPP that needs further investigation.

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Toward high-throughput particle-by-particle micro- and nanoplastics analysis via fluorescence-guided O-PTIR characterization

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Micro- and nanoplastic particles are emerging contaminants of concern for ecosystems and human health. Combined with simultaneous quantification, their characterization remains difficult, especially for small microplastics and nanoplastics. Conventional infrared (IR) spectroscopy is rapid and well-suited for mapping but is diffraction-limited to particles $\geq 10 \mu\text{m}$. Raman spectroscopy can reach sub-micron scales, yet fluorescence background often masks signals, and time problems constrain mapping approaches, favoring particle-by-particle workflows. Optical Photothermal Infrared (O-PTIR) spectroscopy addresses these gaps by coupling sub-micron spatial resolution from a visible probe with the molecular specificity of IR absorption.

Using a mIRage-LS platform with a 532 nm Raman probe and a mid-IR quantum cascade laser, we analyzed secondary sub-micron particles from four priority polymers—polystyrene (PS), polyethylene terephthalate (PET), polypropylene (PP), and polyvinyl chloride (PVC). We obtained diagnostic IR and Raman spectra that enabled confident polymer identification, including reference beads down to 300 nm, indicating high sensitivity and spatial resolution.

To increase the efficiency of micro- and nanoplastic detection in complex matrices, we integrated fluorescence staining with O-PTIR. Fluorescence rapidly localizes candidate particles of interest, after which O-PTIR delivers targeted, interference-free IR spectra. This workflow yields reliable characterization of highly fluorescent sub-micron particles—conditions under which Raman alone after staining is typically ineffective—and reduces time spent via eliminating non-target particles. This combined approach offers strong potential for more efficient, automated, and high-throughput analysis of micro- and nanoplastics in real-world samples.

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From microplastics to microfibers – Modelling scattering and absorbance effects in μ FTIR spectra using machine learning

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Microplastics come in various shapes and sizes. Because of this variety, these tiny particles also have different ways of interacting with electromagnetic waves. For transmission μ FTIR imaging spectroscopy, these interactions can alter the appearance of spectra of the same polymer type. Examples include Mie scattering, resonant Mie scattering, and total absorbance. As a consequence of these physical effects, automatic detection approaches may fail to identify the spectra correctly, which in turn leads to incorrect identification of the particle's contour.

The stated problem becomes even more prominent when microfibers are the target of analysis. While microfibers cause the same effects, their elongated shape introduces additional difficulties. Failure to correctly identify all spectra of a fiber may lead to fragmentation and, thus, inaccurate results in particle counts and length distributions.

Due to their ability to learn complex relationships in spectroscopic data, machine learning algorithms offer a viable alternative to traditional spectral library search for spectrum identification. However, their success in correctly identifying altered spectra ultimately depends on whether the data used to train them reflect a good approximation of the real target application.

In this presentation, we will explore examples of how the size and shape of microplastics and microfibers alter the appearance of IR spectra. Based on sampled polymer spectra, we will showcase how total absorbance and scattering effects can be modelled using machine learning. We will further discuss application cases of microfiber analysis in environmental samples and in residues from textile washing.

High-contrast imaging and characterization of environmental-like microplastic & nanoplastic (eMNPs) by low-voltage transmission electron microscope

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While most studies investigating the physicochemical properties and toxicity of micro- and nanoplastics (MNPs) use manufactured plastic particles—typically spherical, uniform in size, and with homogeneous surface charge—real-world micro- and nanoplastics exhibit practically opposed properties, being highly heterogeneous and irregular in both size and morphology. This discrepancy makes their analysis particularly challenging, as the irregular shape and broad size distribution require advanced imaging techniques, while plastic materials composed of light elements are inherently difficult to visualize using conventional transmission electron microscopy (TEM). Environmental-like micro- and nanoplastics (eMNPs) can range in size from a few nanometers to several micrometers, further increasing the demands on reliable visualization and characterization.

The diverse shapes of environmental micro- and nanoplastics significantly impact their behavior in biological systems, influencing membrane penetration, cellular adhesion, and stress response induction. From an analytical perspective, these characteristics place strong demands on electron microscopy techniques, particularly with respect to contrast. Conventional TEM, typically operated at higher accelerating voltages, often provides insufficient contrast for reliable imaging of polymer-based particles without staining or demanding sample preparation procedures.

In this context, Low Voltage Electron Microscopy (LVEM) represents a uniquely powerful TEM-based approach for imaging micro- and nanoplastics. The LVEM 5 and LVEM 25E systems (Delong Instruments, Brno, Czech Republic) utilize low-energy electrons, whose strong interaction with matter results in exceptionally high intrinsic image contrast, enabling direct visualization of weakly scattering plastic nanoparticles and thin microplastic fragments that are challenging or invisible in conventional TEM. In addition, the LVEM 25E functions as a multimodal analytical platform, combining TEM, STEM and SEM (BSE) imaging with complementary techniques such as dark-field imaging, electron diffraction for crystallographic analysis, and energy-dispersive X-ray spectroscopy (EDS), including elemental mapping. The integration of structural, morphological, and elemental information within a single instrument positions LVEM as an exceptional tool for comprehensive characterization of environmental-like micro- and nanoplastics.

Smart chemistry for seeing the unseen: optical microplastic detection in complex biological matrices

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Accurate detection of micro- and nanoplastics is currently limited by two major challenges: insufficient sensitivity for the smallest particles and loss of biological context during sample preparation. In this lecture, I will present our “smart chemistry” approach to microplastics analysis, which combines advanced optical microscopy with selective fluorescent staining and optical clearing strategies. By pushing fluorescence microscopy towards the smallest detectable particle sizes while simultaneously preserving spatial and biological information, we enable quantitative and imaging-based analysis of microplastics in water, food matrices, and human tissues.

Our methodology integrates tailored digestion protocols for complex matrices with chemical labels that provide high selectivity and sensitivity to plastic particles, followed by optical clearing to suppress background and restore transparency of biological samples. This combination allows direct visualization of microplastics within their native bio-environment, rather than after complete destruction of the surrounding matrix. The approach bridges the gap between bulk analytics and spatially resolved imaging and creates new opportunities for exposure assessment, toxicological research, and regulatory monitoring.

By coupling smart chemical design to state-of-the-art optical microscopy, we move microplastics research beyond counting toward true mechanistic insight into environmental distribution and biological interaction of micro- and nanoplastics.

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Revealing tire wear particles in zebrafish guts by LA-ICP-MS-based elemental fingerprinting and machine learning

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Tire wear particles (TWPs) are an increasingly recognized source of microplastic pollution, released through tire abrasion on road surfaces. Composed of synthetic rubbers, fillers, and pavement fragments, TWPs persist in soils, freshwater, sediments, and air, posing potential risks to ecosystems and human health. Despite their prevalence, detecting TWPs in environmental and biological matrices remains challenging. Conventional techniques, such as FTIR, are hindered by carbon-rich matrices, while pyrolysis-GC-MS provides mass-based information without resolving particle number, size, or spatial distribution.

In this study, we develop a novel approach for TWP detection in biological tissues using laser ablation-inductively coupled plasma mass spectrometry (LA-ICP-MS), a technique used for the analysis of the elemental composition of solid samples, combined with elemental fingerprinting and machine learning. Zebrafish served as a model to explore the feasibility of the presented approach. Multielement signatures enabled differentiation of TWPs from surrounding tissue and paraffin embedding material as well as other natural occurring particles. A random forest classification model trained on selected elemental markers achieved pixel-wise discrimination of elemental images, overcoming variability in particle composition and biological matrices. Independent validation confirmed robust classification performance.

Our findings demonstrate that LA-ICP-MS elemental imaging can overcome current methodological limitations in microplastics research. The presented approach allows spatial mapping of TWPs with a lateral resolution <10 μm , potentially providing insights into their bioaccumulation and ecological and human health impacts. By offering a new route to study TWP occurrence, distribution, and biological interactions, this methodology addresses critical gaps in microplastics monitoring and risk assessment.

Application of total reflection X-ray fluorescence spectroscopy for trace-level metal quantification in labelled nanoplastics

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Growing concern over nanoplastic particles (NPs) in the environment and their potential health risks highlights the need for effective risk assessment tools, such as studies on the uptake of nanoplastics by plants or cells. However, suitable model particles other than commercially available spherical polystyrene particles are lacking. To bridge this gap, we have developed a synthesis procedure for metal- and fluorescently labelled NPs that allows control over the metal element, fluorophore, and polymer type, where we employ total reflection X-ray fluorescence spectroscopy (TXRF) to characterize their elemental composition. It is particularly crucial to know the initial metal weight loading of the NPs for their use in risk assessment studies. Unfortunately, the common technique for quantifying metal weight loadings, namely inductively coupled plasma mass spectrometry (ICP-MS), cannot be used as there is a mismatch between solvents for the polymer and metal materials. Therefore, this work evaluates TXRF - a powerful tool for ultra-trace element analysis - as non-destructive, quantitative method to quantify the low weight loadings of the metal in the NPs. In this presentation the developed TXRF methodology will be introduced. We demonstrate that TXRF can be used for quantification and hence contribute to sensitive detection of metal-labelled NPs within exposure and/or toxicological studies.

Tracking microplastics in zebrafish guts using micro-computed tomography

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Micro-computed tomography (microCT) represents a cutting-edge, non-destructive technique with significant potential to advance microplastic (MP) research. Conventional analytical methods provide robust chemical identification but fail to preserve the spatial information needed to understand MP localisation within biological tissues. Our recent work introduced microCT as a novel imaging tool for three-dimensional visualisation of MPs in intact zebrafish samples. Using optimised scanning protocols and iodine-based contrast enhancement, microCT successfully detected polyethylene MPs as small as 30 µm within zebrafish guts. The technique enabled accurate quantification and localisation of MPs without invasive preparation, maintaining sample integrity and minimising contamination risks. Building on this methodological foundation, microCT was advanced into a practical tool for realistic tracking of MPs in living models. Employing a feeding-based exposure design in zebrafish, we achieved non-destructive visualisation of the ingestion, distribution, and elimination of aged MPs throughout the gastrointestinal tract. This approach allowed temporal tracking of MP passage through the guts, revealing their movement and accumulation patterns under environmentally relevant conditions. Overall, the results confirmed microCT as a reliable and robust method for the first non-destructive identification and tracking of MPs in intact biological samples with high spatial resolution. This methodological framework offers a valuable foundation for future ecotoxicological and biomedical studies on particle transport, accumulation, and elimination, supporting a more comprehensive understanding of the biological impacts of MPs.

Fast und automated microplastics analysis in carbonated beverages by QCI based LDIR - A critical evaluation of spectral range selection and size detection limits

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Microplastics have become an unwelcome ingredient in food and drink, raising concerns about how plastic materials contribute to contamination. This study demonstrates a rapid, automated approach for detecting and characterizing microplastics in carbonated beverages and apple juice using an Agilent 8700 Laser Direct Infrared (LDIR) chemical imaging system. Samples packaged in various

materials such as plastic, glass, aluminum cans, and multilayer cartons were analyzed directly on aluminum-coated filters, a process requiring minimal sample preparation. Using the Particle Analysis method and inbuilt microplastics spectral library within the Agilent Clarity software, microplastics were detected in all beverage types. Polyvinyl chloride (PVC) and polyethylene terephthalate (PET) were identified as the most prevalent polymers. The workflow, including robust quality control and direct-on-filter analysis, highlights the suitability of the 8700 LDIR for microplastics monitoring in food and beverage related applications.

Furthermore, critical aspects such as the selection of the spectral range and the influence of interferences such as natural PA and Mg stearate will be examined and critically discussed in this presentation. The LDIR 8700 was compared with other systems such as the Cary 620 FPA Imaging System and the Cary 630 FTIR spectrometer, and the spectral range was compared to the fingerprint range for all systems. In all cases, polymers were identified with high HQI. The presentation will also demonstrate strategies to identify PA in presence of PA naturally occurring and Mg Stearate in presence of PE.

Microplastics of biodegradable polyhydroxyalkanoates: impact on plant growth and soil health

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The microplastics accumulation in soil and their impact on soil and plant health are emerging environmental problems. Biodegradable plastics were introduced as a solution; among them, polyhydroxyalkanoates, natural bacterial storage polymers, exhibit the most promising properties.

Our research has focused on poly-3-hydroxybutyrate (P3HB). Across different experiments, microbial degradation of P3HB in soil consistently stimulated microbial activity and enzyme suites involved in carbon, nitrogen, and phosphorus cycling. However, this intensification of microbial processes frequently reduced plant performance due to nutrient immobilization and altered soil stoichiometry.

In maize, a clear dose-dependent trade-off was observed: P3HB addition increased microbial biomass carbon and total carbon stocks, but at application rates $\geq 1\%$ (w/w) it caused acidification, nutrient imbalances, and strong reductions in aboveground biomass. Nutrient fluxes to the crop were impaired, with significant decreases in tissue N, P, and K concentrations at higher doses, highlighting competition between roots, rhizobiota, and P3HB-degrading microbes.

In lettuce grown under varying soil textures, P3HB amendment also enhanced microbial activity, yet aboveground and root biomass were markedly reduced. These effects were amplified in sandier soils, where microbial communities shifted toward specialized degraders, further intensifying nutrient immobilization and limiting plant nutrient availability.

Therefore, although P3HB microplastics have positive impact on soil microbial activity and organic carbon pools, their degradation and the associated microbial competition lead to phytotoxic effects. Such impacts extend beyond reduced plant vigor to long-term changes in soil fertility and organic matter turnover. As the agricultural use of bioplastics expands (e.g., mulches, coatings, delivery systems), understanding and managing these soil–plant trade-offs is essential for sustainable use of biodegradable plastics.

Uncovering metabolomic dysregulation in plants caused by exposure to nano - and microplastics (NMPs)

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This study provides a novel and comprehensive evaluation of metabolic disruptions induced by nano- and microplastics (NMPs) in plant systems, using *Lactuca sativa* as a model species. Controlled hydroponic exposure experiments combined with high-resolution mass spectrometry revealed that plastic nanoparticles interfere with key metabolic pathways by modifying the abundance and activity of polyunsaturated fatty acids (PUFAs). This highlights a previously unrecognized link between NMPs and plant biochemical regulation.

Particle size emerged as a critical determinant of the response: the smallest nanoparticles (100 nm and 200 nm) caused the most severe metabolic alterations, with 100 nm particles producing the largest shifts in PUFA-associated molecular masses, as indicated by pronounced variations in chromatographic peak areas. In particular, the molecular ion at m/z 293.2469—tentatively assigned to the methanol adduct of the glycerolipid (6Z,9Z,12Z,15Z)-octadeca-6,9,12,15-tetraenal—was most affected in the 100 nm treatments. Two additional ions (m/z 307.2264 and m/z 309.2415) displayed similar sensitivity to smaller particles, reinforcing the size-dependent character of these interactions. Conversely, the methanol adduct of α -linolenic acid (m/z 311.2575) showed a more gradual response across particle sizes, suggesting a different interaction mechanism.

Larger particles (500 nm and 1000 nm) exerted notably weaker effects, showing that nanoscale plastics are the principal drivers of PUFA downregulation. Overall, these findings demonstrate the utility of high-resolution metabolomics for the robust assessment of NMP-induced biochemical alterations and offer valuable insights into their potential implications for plant health and food quality.

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Dietary microplastic uptake increases risk-taking behaviour in a widespread decomposer, the common pill bug (*Armadillidium vulgare*)

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Exposure to microplastics (MPs), plastic fragments ranging from 1 µm to 1 mm in diameter, has become a growing concern for wildlife and humanity. MPs are now known to accumulate freshwater, seawater and even the atmosphere in soil, exposing living organisms worldwide to these pervasive ecological stressors. While research on the physiological impacts of MPs on wildlife is growing, studies focusing on how MPs influence animal behaviour remain scarce. Even fewer investigations explore how MPs affect components of among- and within-individual behavioural variation. This study aimed to assess the effects of prolonged dietary exposure to MPs on individual variation in risk-taking behaviour in a widespread decomposer, the common pill bug (*Armadillidium vulgare*). Our results reveal significant impacts of MPs at multiple levels of behavioural variation: (i) the average level of risk-taking increased and (ii) a correlation emerged between mean risk-taking and residual within-individual variation where risk-takers became less predictable in the MP-exposed group. These findings demonstrate that MPs alone can alter ecologically relevant behaviours. In this case *A. vulgare* may face heightened predation risk due to behavioural changes induced by MP exposure highlighting the broader ecological consequences of microplastic pollution.

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Exploring the application of metal-doped nanoplastics in environmental studies: Uptake and distribution in duckweed *Lemna minor*

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In this study, we investigated the potential of metal-doped nanoplastics as traceable model particles for environmental research in particular with freshwater plants. Three types of non-spherical nanoplastics derived from different polymers were synthesized and doped with metal–organic complexes of europium (Eu), iridium (Ir), and platinum (Pt). Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) mapping enabled direct visualization of metal distribution in plant tissues and provided clear evidence of particle uptake by the aquatic plant *Lemna minor*. Isotope maps and carbon–metal signal overlays revealed distinct accumulation patterns depending on the type of polymer and doped metal. These findings demonstrate that metal-doped nanoplastics serve as stable and traceable model systems suitable for studying nanoplastic–biota interactions in aquatic ecosystems. LA-ICP-MS proved to be an effective tool for visualizing the uptake and distribution of nanoplastics in biological tissues at the microscale.

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When pollutants interact: triclosan reverses nanoplastic-induced parasite infection in *Daphnia galeata*

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Nanoplastics have been shown to cause drastic effects on both phytoplankton and zooplankton species in aquatic ecosystems. Their interaction with other organic pollutants can alter nanoplastics toxicity in a host-parasite context. We argue that the joint exposure of nanoplastics and triclosan reduce the susceptibility of *Daphnia* to infection compared to exposure to nanoplastics solely. We studied the effect of nanoplastics and triclosan on host-parasite interactions by exposing the zooplankton *Daphnia galeata* to the parasitic yeast *Australozyma monospora* without plastic or triclosan and two 50 nm nanoplastics concentration categories (0.5 mg/L and 5 mg/L) as well as at two triclosan levels (30 µg/L and 0 mg/L). Infection prevalence and host viability varied significantly with nanoplastics concentration ($p = 0.036$) and marginally with the interaction between nanoplastics concentration and triclosan exposure ($p = 0.055$), but not with triclosan exposure alone. The percentage of infected hosts or infection prevalence increased with higher nanoplastics concentrations, from $33.3\% \pm 12.2\%$ at 0 mg/L nanoplastics to $81.8\% \pm 11.6\%$ at 5 mg/L nanoplastics. Parasite reproduction and disease transmission did not change with nanoplastics, triclosan, or their interactions. Considering the ubiquity of parasitism in natural systems and its role in shaping ecosystem functioning, these results emphasize the importance of integrating ecological interactions into assessments of the ecological consequences of plastic pollution and other organic pollutants in aquatic ecosystems.

Evaluating microplastic contamination in endangered wild species: analytical method development for detection in lung tissues

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A critical aspect in the development of analytical methods for the detection and quantification of microplastics (MPs) in biological tissues is their validation, which ensures the precision, accuracy, and reliability of the results. Recovery performance is a key parameter, as it directly influences both accuracy and precision. A precise method yields reproducible recoveries, while low or inconsistent recoveries may lead to under- or overestimation of actual MP concentrations. Another essential factor is sample representativeness, which determines how accurately the analyzed portion reflects the characteristics of the entire tissue. This depends on both sample size and proper homogenization to achieve a uniform distribution of MPs within the matrix.

In this study, an analytical method was developed and validated for the detection of MPs in animal lung tissue. Key parameters—such as sample size, oxidizing reagent, and inorganic saline solutions for density separation—were optimized. The method was validated using four MP polymers: low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), and polyethylene terephthalate (PET), achieving mean recovery rates above 70% for all materials.

Conducting comprehensive and standardized studies is essential to accurately assess exposure of individuals and populations to airborne MPs. While most research has focused on marine systems, terrestrial studies remain scarce. This project advances the understanding of inhalation exposure in terrestrial environments by evaluating the presence of microplastics in the lung tissue of endangered and vulnerable gazelles from the Saharan Fauna Rescue Park. Analyses include fetuses and newborns, and the presence of fibers and fragments has been confirmed in adult individuals.

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Toxicity of polyethylene terephthalate micro- and nanoplastics and their degradation products in liver and intestinal cells

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Plastic pollution represents an escalating global challenge, with large quantities of plastic waste contaminating natural environments. Through a combination of physicochemical and biological processes, larger pieces of plastic break down into small particles known as microplastics (<5 mm) and nanoplastics (<100 nm) (MNPs). The widespread occurrence of MNPs raises concerns about their impact in human health. Once in the human body, MNPs and their degradation products will interact with different types of cells, however, their potential toxic effects remain largely unknown. Polyethylene terephthalate (PET) is a widely used plastic material that can degrade into mono(2-hydroxyethyl) terephthalate (MHET), bis(2-hydroxyethyl) terephthalate (BHET), terephthalic acid (TPA), and ethylene glycol (EG), which are recognized as the main hydrolysis products of PET. In this study, the cytotoxic effects of PET-MNPs and respective degradation products was assessed on human intestinal and liver cell lines. The results revealed cytotoxic effects for PET MNPs, particularly at higher concentrations, however, some degradation products exhibited greater toxicity than their corresponding MNP counterparts when tested at equivalent doses. These results emphasize the importance of studying the potential cytotoxic effects of MNPs and their degradation products.

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Polystyrene nanoplastics oral exposure promotes Insulin resistance in mice

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Micro- and nanoplastics (MNPs) have recently emerged as environmental contaminants of concern. Ingestion, particularly from food and beverage packaging, is a major exposure pathway. Experimental evidence suggests that chronic dietary exposure to these particles may contribute to metabolic alterations, including insulin resistance.

This study investigated whether oral exposure to polystyrene nanoplastics (NP-PS) promotes insulin resistance in mice. Two-month-old male mice were randomized into four groups: control diet (Chow), Chow + NP-PS (1 week), Chow + NP-PS (3 weeks), and high-fat diet (HFD, 60% fat). NP-PS were administered via oral gavage at 30 mg/kg/day, three times per week.

Short-term exposure (1 week) did not impair glucose tolerance, whereas 3-week exposure significantly reduced glucose tolerance compared with controls. Mice exposed to NP-PS for 3 weeks also displayed a significant body weight gain relative to control animals. In both exposure periods, NP-PS increased adipocyte size (area) a hallmark of insulin resistance, and promoted adipose tissue accumulation, both visceral and subcutaneous.

These preliminary findings indicate that NP-PS ingestion can promote insulin resistance, possibly through visceral adipose tissue hypertrophy. Future work will focus on elucidating the underlying molecular mechanisms.

Unraveling the interaction of environmental microplastics with human reproductive fluids

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This study investigates the presence, behavior, and potential implications of microplastics (MPs) in undigested human semen and prostate tissue. By preserving the physiological structure of the semen and avoiding chemical digestion, the spatial localization and morphological characteristics of MPs within the intact biological matrix were examined. Semen samples from five volunteers were analyzed using a combination of fluorescence microscopy and micro-Raman spectroscopy. MPs ranging from 2 to 13 μm in size, with irregular shapes, were consistently detected in semen samples. The identified polymers included polypropylene, polyethylene, polystyrene, polyester, polyethylene terephthalate, and polyvinyl chloride. Notably, no MPs were observed adhering to or penetrating sperm cells, suggesting a lack of direct interaction at the microscale. Prostate tissue analysis revealed larger MPs (up to 60 μm), predominantly above 30 μm , indicating a potential filtering role of the prostate in retaining larger particles while allowing smaller ones to reach the ejaculate. The size discrepancy between semen and prostate samples supports the hypothesis that the prostate acts as a selective barrier for MPs. While the absence of direct MP-sperm interactions suggests a lower risk of cytotoxic or genotoxic effects, the observed correlation between MP presence and reduced sperm motility in previous studies cannot be overlooked. The findings highlight the potential clinical implications of MP exposure on male reproductive health, including possible effects on sperm function, prostate health, and overall fertility. Future research should focus on the smallest particle fractions, particularly nanoplastics, to fully elucidate the risks associated with nanoscale plastic exposure.

A toxicological shift: comparing the cytotoxicity of PE, bioplastics and fungal degradation by-products

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The proliferation of micro/nanoplastics (MNPLs) is a well-established global threat. However, a critical gap exists in our understanding of their long-term fate and the toxicological profile of their degradation by-products. This question is equally urgent for "green" alternatives, such as bio-plastics.

Our study compared the cytotoxicity of fuel-based polyethylene (PE) MNPs and bio-based biodegradable counterpart, starch-based (Bio MNPs) in different human cell lines. In addition, it was further evaluated cytotoxicity of the generated degradation by-products after previous incubation of PE-MNPs with the marine fungus *Zalerion maritimum*.

Challenging the common assumption that biodegradation inherently leads to detoxification, our results reveal a significant and deeply concerning finding: the degradation by-products generated from the fungal incubation with PE-MNPs were demonstrably more cytotoxic than either the original, intact MNPLs or the fungus itself.

This finding suggests that the environmental breakdown of plastics, far from being a simple solution, may paradoxically increase their toxicological impact. We demonstrate that the degradation process itself can create a scenario more hazardous than the parent pollutants. These results have profound implications, challenging the perceived safety of both conventional and bio-based plastics and highlighting a critical, unexamined pathway for public health exposure.

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Disruption of the microbiota – Immune axis by mixed nano- and microplastic exposure in C57BL/6J mice

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Background: environmental plastics gradually degrade into microplastics (MPLs) and nanoplastics (NPLs) through biological, chemical, and physical processes. Smaller particles can enter the bloodstream via the respiratory tract and potentially affect the gut–lung immune axis, whereas larger particles interact mainly with the intestinal environment, potentially impairing immune homeostasis. To date, data on the accumulation of N/MPLs in mammalian tissues are limited, yet such information is essential for evaluating potential human health risks.

Aim: to investigate the effects of N/MPL exposure on the microbiota–immunity axis in vivo using a C57BL/6J wild-type mouse model.

Methods: in C57BL/6J wild-type mice were administered polyethylene (PE) and polyethylene terephthalate (PET) particles via oral gavage. The V3–V4 hypervariable region of the 16S rRNA gene was sequenced from lung and colon samples to assess microbiota composition. In addition, inflammatory cytokines were quantified in plasma by multiplex technology. Finally, T cell populations were characterized in the spleen by cytofluorimetry and the colon metabolism gene expression profiles were analysed by using Nanostring approach.

Results: we documented some differences at genus level after microplastic treatment respect to control in the colon microbiota. In addition, we observed an increase in plasma of IL-1 β , a renowned pro-inflammatory cytokine, in PE treatment compared to control and PET treatment.

Conclusions: we documented some significant changes in the microbiota-immunity axis after the treatment with N/MPLs. Finally, the assessment of MP and NP exposure in mice models offers a valuable tool to assess health risk of plastic exposure to animals and parallel to humans.

Biofouling of microplastics surfaces alters microplastic–nutrient interactions in aquatic environments

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Nutrients and their cycling are fundamental for maintaining energy flow, food webs, biodiversity, and overall productivity in aquatic ecosystems. However, these essential processes can be disrupted by pollutants that modify aquatic chemistry, exert toxic effects on organisms, and alter biogeochemical pathways and microbial communities. Among emerging contaminants, microplastics (MPs) are now ubiquitous in aquatic environments, yet their role in nutrient cycling remains poorly understood.

In this study, we investigated how biofilm formation on MP surfaces influences nutrient–microplastic interactions. Two types of MPs (polyethylene (PE) and polybutylene adipate terephthalate (PBAT)) were aged in freshwater for eight weeks to allow biofilm development. Microbial analysis revealed differences in biofilm composition and structure depending on the MP type. Adsorption experiments were then performed to evaluate the interactions of phosphorus and different nitrogen forms (ammonium, nitrite, and nitrate) with pristine and biotically aged MPs. Our results showed that biofilm presence significantly affected nutrient–microplastic interactions in most cases. Orthophosphates and ammonium nitrogen adsorbed in significantly lower quantities onto aged PBAT MPs, while biofilm formation did not influence their adsorption on PE MPs. Conversely, biofilm presence enhanced nitrite adsorption on both MP types, but only when the biofilm was still viable, suggesting microbial uptake. Nitrate adsorption was highest on pristine PBAT MPs, whereas aged PE MPs exhibited higher adsorption of nitrate once the biofilm was no longer viable, indicating a shift toward physical adsorption. Overall, our findings highlight that biofouling can substantially modify how different types of MPs interact with key nutrients, potentially altering nutrient cycling dynamics in aquatic ecosystems.

Biofilm formation on common plastics: influence of polymer type and particle size

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Biofilm formation on plastic materials poses serious challenges in environmental, industrial, and healthcare settings. Widely used polymers such as polystyrene (PS), polylactic acid (PLA), polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride (PVC) are durable and often exposed to microbes, making them ideal surfaces for colonization. In healthcare, biofilms on medical devices can be a source of persistent infections and increase antimicrobial resistance, raising treatment complexity and healthcare costs. In the food industry, biofilms on plastic equipment contribute to hygiene issues, contamination, and economic losses due to downtime and cleaning. Microbial adhesion depends on surface features like hydrophobicity, roughness, and charge; some polymers favor microbial colonization, while others inhibit it. Beyond material type, plastic size critically affects biofilm dynamics, especially in industrial contexts. Smaller particles (e.g., microplastics) have larger surface-area-to-volume ratios, which enhance microbial attachment and nutrient transfer, accelerating biofilm development. *Pseudomonas aeruginosa* is commonly used as a model organism because of its robust biofilm formation and clinical importance; therefore, it is ideal for laboratory-scale biofilm assays.

This study systematically compared biofilm formation of *P. aeruginosa* on different plastics and investigated the particle size-dependent effects as well. A tetrazolium salt-based MTT assay quantified the metabolic activity of biofilm cells, producing consistent and reproducible results across materials and size categories. Biofilm formation varied by polymer and size: *P. aeruginosa* showed the highest activity on PS and LDPE, and the lowest on PVC and PET. Importantly, smaller plastic particles supported greater biofilm growth, consistent with their higher surface availability. These results demonstrate that both the physicochemical properties and the size of plastics are key factors shaping biofilm development, with practical implications for industrial hygiene and material design.

Understanding the interactions between plastics and metals: plastic-related governing factors and metal leaching behavior

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The accumulation of plastics in aquatic environments can disrupt the natural biogeochemical balance by adsorbing and releasing trace elements. This process can have harmful effects on ecosystems, especially for potentially toxic elements. The present study, therefore, investigates the adsorption and release of metals by plastics, considering key influencing factors such as polymer type, presence of additives, and ultraviolet degradation. The adsorption capacity of plastics was studied for copper and lead by kinetics experiment in aqueous solutions over a 72-hour period. A conventional polymer (LDPE) and a compostable one (PBAT) were used as adsorbent, both in additive free pellet form and as commercial finished products such as plastic bags. Samples were also degraded by artificial UV irradiation for one month. Additionally, the release of additives under acidic conditions using HNO₃ 2% v/v was evaluated: the release of inorganic additives such as tin, antimony, titanium, and zinc was analysed after one and two weeks of experiment. This experiment was performed on the same plastic materials used in the adsorption experiments. The results showed that metal adsorption is mainly influenced by the presence of additives and, to a lesser extent, by UV aging and polymer type. In fact, additive containing samples showed higher adsorption capacity compared to additive free pellets. Regarding the leaching experiments, all studied samples released various elements at different concentrations, especially the additive-containing samples leached higher concentration and total amount of elements compared to the pure samples. This process strongly depends on the plastic material and the metal species involved. Overall, both metal adsorption and additive release were observed to be influenced by the different factors tested at a varying extent. Next steps to better understand their environmental implications and long-term effects will include experiments under realistic environmental conditions and investigations into the speciation of the released metals.

The influence of surface chemistry on the degradation of polystyrene nanoplastics

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In recent years, concern has risen on the effect of nanoplastics (<1 μm , NPs) on human and environmental health. To understand potential health effects, hazard characterization and therefore physicochemical characterization of NPs is key. In this work, a toolbox of analytical methods was employed to improve the understanding of the fate of nanoplastics exposed to UV-radiation, which highlighted specifically the importance of surface characterization. Surface-sensitive methods Photo-induced Force Microscopy (PiFM) and Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) revealed selective surfactant removal from PS spheres by oxidative treatment. Subsequently, Scanning Electron Microscopy (SEM) revealed that surfactant presence influenced the morphological evolution of PS NPs upon accelerated UV-weathering. Particles without surfactant shrank uniformly upon UV-exposure, conserving a spherical morphology, whereas particles with surfactant degraded at specific weak points on the particle, leading to increasingly indented particles at prolonged weathering times. Attenuated Total Reflection Infrared (ATR-IR) spectroscopy, PiFM and ToF-SIMS elucidated differences in the (surface) oxidation of the weathered particles, which was influenced by the initial presence of surfactant prior to weathering. Despite the differences in morphology and (surface) chemistry after the UV-weathering of particles with and without surfactant, no effect was observed on the metabolic activity and NF- κ B activity of differentiated THP-1 Blue macrophages.

Our findings show that surfactant removal and subsequent environmental weathering significantly alters the (surface) characteristics of polystyrene nanospheres. However, these alterations do not directly translate into altered toxicological response. This highlights the need for further research on the complex interaction between particle size, surface chemistry and biological interaction in the evaluation of the potential risks of nanoplastics. Systematic characterization of the particles used in hazard assessment studies will be key to more accurate understanding of the nanoplastic impacts on health and the environment.

Comparative adsorption study of 4-methylbenzylidene camphor on true-to-life microplastic particles derived from post-consumer polymers in water

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Microplastic particles represent chemically and morphologically complex materials that can significantly influence the environmental fate of hydrophobic organic contaminants. Nevertheless, most existing adsorption studies are conducted on virgin polymer standards, which inadequately reflect the surface characteristics and physicochemical heterogeneity of microplastics present in natural environments. In this study, the adsorption of 4-methylbenzylidene camphor (4-MBC), a representative organic ultraviolet (UV) filter and known endocrine-disrupting compound, was examined using true-to-life microplastic particles produced from post-consumer polyethylene terephthalate (PET), polystyrene (PS; two sources), polypropylene (PP), and polyethylene (PE). The materials were obtained by cryogenic milling of plastic waste, which generated irregularly shaped fragments characterized by pronounced surface roughness and particle-size distributions comparable to those of mechanically degraded environmental microplastics. Adsorption experiments revealed that equilibrium was established after approximately 36 hours. The kinetic data were evaluated using pseudo-first-order, pseudo-second-order, and Elovich models, and the Elovich model exhibited the best agreement with the experimental results, indicating that the adsorption of 4-MBC onto selected true-to-life microplastic particles proceeded predominantly through surface-controlled chemisorption on energetically heterogeneous sites. The equilibrium data were well fitted by the Langmuir isotherm, suggesting monolayer adsorption and the presence of a finite number of active sites on the particle surfaces. The adsorptive affinity decreased in the order PET > PS > PP > PE, reflecting the combined effects of polymer aromaticity, polarity, and surface heterogeneity. The equilibrium adsorption capacities (q_e) ranged from 45 $\mu\text{g g}^{-1}$ for PET to 19 $\mu\text{g g}^{-1}$ for PE, while the maximum adsorption capacities (q_{max}) obtained from Langmuir modeling varied between 23 $\mu\text{g g}^{-1}$ and 62 $\mu\text{g g}^{-1}$. The results highlight the polymer-dependent nature of adsorption and confirm that employing microplastic particles derived from post-consumer materials yields a more realistic assessment of pollutant–polymer interactions.

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Evaluating the role of manufacturing and post-processing in the release of metal-containing additives from polylactic acid products

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Plastic materials are extensively employed in a broad range of everyday applications. In this context, polylactic acid (PLA) has gained particular attention as a biodegradable alternative to conventional polymers. However, the presence of additives introduced during plastic production, such as catalysts used in the polymerization processes is raising concerns for human and environmental health. Specifically, PLA synthesis typically involves the use of tin-based catalysts, which are known to exhibit toxicological effects. A major issue concerning such additives is their persistence within polymer matrices, which may lead to leaching into aquatic environments after dispersal of this material. In this study, a variety of PLA-based consumer products were examined, including 3D printing filaments of different colours, disposable cups, cutlery, and coffee cup lids, to investigate the importance of manufacturing process in the release of tin-containing compounds. Filaments were analysed both in their pristine form and after extrusion at 175 °C, to evaluate the influence of thermal and mechanical processing on additive behaviour. Total metal content was determined with acid digestion followed by inductively coupled plasma mass spectrometry (ICP-MS). Leaching experiments were carried out using various extractants to simulate different environmental or usage conditions, with resulting solutions analysed by ICP-MS for quantitative assessment. Both pristine and post extraction samples were also characterized via ATR-FTIR spectroscopy to observe surface functional groups. The results demonstrate that processing conditions affected the release behaviour of metallic additives. Tin, showing total concentrations ranging from 15 to 50 mg/kg, exhibited increased leaching following extrusion and in items intended for food contact compared to pristine filaments. Nonetheless, pre-extrusion filaments showed some differences in leaching, attributable to pigment-related additives. Overall, these findings highlight the importance of manufacturing parameters and post-processing treatments in governing the potential release and environmental fate of hazardous additives from PLA-based materials.

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Heterogeneous distribution of small MPs in the water column: a perfect hiding place for plastic

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The @OpenPLAS group has been working since 2018 on the study of microplastics (MPs) in the Atlantic region down to 1,200 m depth, focusing their research so far on the eastern North Atlantic. The group has sampled the water column at least once a year in different locations around the Canary Islands, detecting that the distribution of microplastics does not follow a homogeneous pattern, either horizontally or vertically.

The vertical distribution is influenced by the input of different water masses, such as the Mediterranean Water (MW) (Vega-Moreno et al., 2024), while the horizontal heterogeneity appears to be affected by current velocity between other factors, among other factors, such as the fact that they accumulate in patches. So far, there is no scientific evidence of the total amount of microplastics in the entire water column—only discrete measurements at specific points—but the number of particles collected is expected to be related to the speed at which they move. This is because the spatial density of the particles is inversely proportional to their velocity: when they move more slowly, they remain longer in the observed region, increasing the number present at a given instant and therefore yielding a higher measured concentration than at another sampling point where the current speed is higher, even if the total particle flux per unit time is the same.

This phenomenon could lead to an underestimation of the values measured so far, with the water column potentially representing a vast reservoir of small microplastics that could explain the differences highlighted by the scientific community between the estimated and observed values. Could the water column be where the missing microplastics are found?

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Environmental aged plastic characterization

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Plastic pollution represents a global environmental concern. Marine and coastal environments are considered major sinks for plastic litter. Plastics released into the marine environment undergo long-term weathering processes that can alter their physical and chemical properties. In this study, we investigated environmentally aged plastics (approximately 50 years old) collected from coastal environments, focusing on the presence and relevance of associated chemical compounds after decades of environmental exposure. A set of plastic items was recovered from the Spanish coasts, spanning production periods from the 1960s to the 1990s, together with polystyrene pellets. These samples represent different polymer types, uses, and environmental histories. Plastic items were analysed to characterise their polymer compositions along with the degradation state and to evaluate the occurrence of inorganic and organic compounds of potential environmental concern. This approach allowed us to capture both polymer degradation and potential surface contamination. Our results highlight that legacy plastics can act as long-term reservoirs of chemicals of concern, even after prolonged environmental exposure. By combining complementary analytical techniques, this study provides insight into the environmental aging that can profoundly alter plastic materials, both at the polymeric and surface levels, with important implication for their toxicological effects in marine environments.

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Towards standardized methods to assess microplastic pollution and its links to soil properties and management in Mediterranean agricultural soils

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Research on microplastics has largely focused on aquatic systems and marine pollution. In contrast, studies on soil microplastics are much more recent, even though their abundance in soils may exceed that in aquatic environments. This discrepancy likely reflects the complex pathways and challenging matrices characteristics of terrestrial systems. One of the major limitations in this field is the lack of standardized methods for sampling, extraction, purification, and identification/quantification of microplastic particles in soil samples.

The presence of microplastics in agricultural soils is particularly high due to management practices such as use of reclaimed water for irrigation, the application of sewage sludge or certain compost types as fertilizers, and the use of plastic films for mulching. Different polymer types may influence soil health, functionality, and microbial communities in diverse ways. Accordingly, this study aims to quantify and characterize microplastic pollution in agricultural soils of Catalonia (NE Spain) and to explore its relationship with soil physicochemical properties, fertilization regimes, and management practices.

Soils were collected from twelve different fields, each characterized by a distinct crop and specific management approach, ranging from conventional inorganic fertilization to organic amendments and biochar applications. To ensure comparability across studies, it is essential to establish standardized protocols and baselines for microplastic contamination in Mediterranean soils. A reference approach was developed for this study, covering soil sampling, extraction, and LDIR-based identification of microplastics. This work and its preliminary results will contribute to the development of harmonized methodologies for soil microplastic assessment and support evidence-based strategies to mitigate plastic pollution in agroecosystems.

Assessment of indoor airborne microplastics in a high school environment

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Microplastics, defined as plastic particles smaller than 5 mm, have recently emerged as a new category of air pollutants, adding to the complexity of environmental contamination. While the adverse health effects of airborne microplastics remain under investigation, growing evidence indicates their potential to affect respiratory health and overall indoor air quality. Despite increasing attention to outdoor microplastic pollution, relatively little is known about their presence, variability, and chemical composition in indoor environments—particularly in educational settings where exposure may be continuous. This research conducted a year-long assessment of microplastics in a high school's indoor air using a passive deposition sampling approach. Airborne particles were collected weekly on pre-cleaned filters, which were replaced each Monday before classroom activities began. Duplicate filters were used each week to ensure data consistency, yielding 106 samples over twelve months. Microplastic particles were subsequently examined for their abundance, morphology, color, and polymeric composition using optical microscopy and a LUMOS II micro-FTIR spectrometer. The study found significant temporal fluctuations in microplastic concentrations, with values ranging between 0.25 and 7.06 MP/cm². The highest particle loads were observed during active school periods, while the lowest levels occurred during vacation months. Fibrous microplastics dominated the samples, followed by a smaller proportion of irregular fragments. The prevalence of fibers suggests that textiles, classroom furnishings, and synthetic materials are likely primary contributors to indoor microplastic pollution. These findings highlight that prolonged indoor exposure may represent a notable pathway of microplastic intake for students in educational environments.

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Microplastics in pristine karst caves of the Timavo system: baseline contamination and methodological insights from inaccessible environments

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Data on microplastic (MP) contamination in natural caves are extremely scarce, particularly for deep, human-inaccessible systems. Here, we report on the first integrated investigation of MPs within the Timavo karst system (NE Italy–Slovenia), combining environmental characterization with a hierarchical sampling approach to assess both contamination patterns and methodological reliability. Sampling was conducted in three caves hydraulically connected to the underground Timavo River: Trebiciano Cave (a classical and partially visited site), Luftloch Cave (a newly discovered pristine cavity), and Maucci Cave (reachable only by cave diving). Sediment samples were collected along river-to-slope transects under strict contamination control, and MPs were isolated and characterized by μ FT-IR spectroscopy.

Our results reveal that microplastics reach even the most remote karst environments, transported by river floods and redistributed along cave slopes according to hydrodynamic and density-dependent processes. Despite the absence of direct human inputs, contamination was consistently detected in all sites, indicating a dominant riverine pathway. The hierarchical design further demonstrated that most of the spatial variability occurs at small and medium scales (replicates and subareas), highlighting the need for structured replication to obtain reliable contamination estimates. Overall, this work provides the first global baseline of MP occurrence in pristine, deep karst caves and offers methodological guidance for designing robust monitoring protocols in subterranean environments where morphology strongly influence contaminant deposition.

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Microplastic sampling and analysis in the MicroDrink and PlasticDustCloud projects

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In the past years microplastics (MPs) were found in different environmental compartments, however, in contrast to well researched seawater, occurrence and effects of MP in surface water, groundwater and air are less investigated.

Because of the lack of integrated MP management in water environment – especially those used for drinking water supply of the Danube River Basin (DRB) region –, effective monitoring tools, and improved policies to mitigate MP emission and reduce pollution are urgently needed. As a first step, EU Directive 2020/2184 identified MPs as potentially hazardous substances and issued sampling and analysis methodology in Commission Delegated Decision C(2024) 1459.

To start collecting EU DWD harmonized data, during MicroDrink Danube Interreg Project, microplastics are monitored in 9 designated transboundary pilot sites in 3 clusters (karst, intergranular, surface/bank filtration) representing the vast majority of DRB drinking water resource types. Following sampling knowledge transfer, during one year-long monitoring campaign samples are analyzed harmonized to the directive's strict QA/QC protocols. As an outcome of the project, a comprehensive online MicroDrink knowledge base will be established, meanwhile relevant international stakeholders will be engaged.

As potential source of MPs to water environment, air samples have been globally analysed during the PlasticDustCloud project by Eurofins. Sampling was conducted through a harmonised wetdry deposition method. Samples were collected in parallel on 12 sites in 9 countries on 3 continents during a week-long exposure period. Results revealed varying deposition rates depending on site and detection technology: up to 1,250 (median 143) particle/m²/day and 3,110 (median 19) µg/m²/day, using vibrational spectroscopy and thermoanalytical technologies respectively. The most frequently identified polymers were polyethylene (PE) and polypropylene (PP), reflecting global plastic production trends. In addition to plastics, tire wear particles (rubbers) were identified, with levels reaching up to 304 (median 2.4) µg/m²/day, highlighting road traffic as an additional significant source of microplastics.

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Scanning probe microscopy methods to characterize nanoplastics from baby bottles

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Nanoplastics (NPs) are making an entry in recent years as the more complicated and invasive variant of microplastics (MPs). Although much is known and studied on MPs, the health and environmental effects of NPs are hard to quantify as their chemical nature and extremely small size (< 1 µm) make it hard to properly characterize them.

Baby bottles, or infant feeding bottles (IFBs), have been a popular case-study for the mitigation of nanoplastics as infants are likely to be more sensitive towards hazards, and IFBs are a specific point source to them. Whereas some reports show particle formation during daily IFB use, others state this is due to precipitating leachates instead of NP generation. Here, we measure particles and leachates formed during the regular use of IFBs, with an emphasis on the particle characteristics and physical properties using high-rate AFM and quantitative nanomechanical mapping, complemented by their infrared spectrum measured using PiFM. These scanning probe microscopy techniques are demonstrated to give detailed information on the physical *and* chemical properties of individual nanoparticles, showcasing their great potential within the MNP field.

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Degradation and deep distribution of small microplastics for polyethylene and polypropylene in the Canary Islands waters

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Polyethylene (PE) and polypropylene (PP) are the most abundant polymers on the ocean surface due to their low density, but they have also been detected at great depths. In the marine environment, these plastics are exposed to weathering processes, including photodegradation, chemical oxidation, and physical abrasion over a prolonged period of time due to their high resistance and permanence, which alters their physicochemical properties and promote the release of plastic additives into the environment. The Canary Islands, located under the influence of the North Atlantic Subtropical Gyre, have been identified as a hotspot for marine litter, showing high concentrations of floating and submerged plastics. This study aimed to assess the presence, composition, and degradation state of small microplastics (SMPs) in the open ocean surrounding the Canary Islands, exploring their vertical distribution and weathering processes. Between 2021 and 2022, SMPs (100 µm–1 mm) were obtained from two mesoscale eddies (50–1200 m depth) during oceanographic cruises aboard the R/V Ángeles Alvariño. Sampling employed Niskin bottles and bottle-net systems, and polymer composition was determined using Micro-Fourier Transform Infrared Spectroscopy (µFTIR).

The results revealed that as weathering progressed, the polymer chains underwent oxidation and fragmentation, forming hydroxyl (-OH), carbonyl (C=O), and olefinic (C=C) groups. These transformations are shown through new absorption bands between 3500–3000, 3100–3000, 1850–1650 cm⁻¹, altered the original FTIR signatures, complicating the identification of the polymers. Several degraded PE and PP fragments were classified as oxidized polymers (OxPol). Despite their buoyancy, PE, PP and OxPol were detected throughout the entire water column, even below 1000 m depth, demonstrating that degraded buoyant polymers can accumulate in deep waters. The findings underscore the importance of combining advanced polymer analyses with vertical sampling to better understand the transport, transformation and fate of microplastics in deep-sea environments.

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Investigating the impact of Extreme Weather events on microplastic pollution in intertidal sediments

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In recent years, the west coast of Ireland has been exposed to an increasing number of extreme weather events, including storms, strong winds, and prolonged periods of precipitation. Such events play a key role in the mobilisation and transport of Microplastics (MPs) in marine coastal ecosystems. Yet, most studies focus on MP abundance and distribution at a single time point. MP concentration and distribution are highly variable over time, driven by factors such as tides, currents, and MP morphology. As the duration, frequency, and intensity of storm events are projected to increase due to anthropogenic climate change, a more targeted approach to monitor temporal fluctuations of MPs is necessary to mitigate their environmental influence. This study aims to determine the impact of extreme weather events on the distribution and abundance of MPs in intertidal sediments. A baseline for microplastic levels was established by collecting samples from 2 corresponding spring and neap tides during a dry period in June 2025. A high-frequency sampling approach was carried out before and after three storm events at four sites in the Galway Bay. The findings of this study will provide insight into MPs' real-time movements following a storm event, aiding the development of monitoring protocols and management strategies for coastal pollution.

Quantification of microplastic contamination in Sava River (Slovenia): Lessons learned from Aquatic Plastic project

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Monitoring of microlitter (litter between 1 µm and 5 mm in size), which consists mostly of microplastics (MP), based on the Marine Strategy Framework Directive (MSFD), has started in the Slovenian sea more than 10 years ago. Considering the estimates that 80% of marine litter sources are land-based (with 85% of this litter being plastic) and that rivers are major pathways for transporting litter to the sea, it is surprising that more than 15 years after the MSFD came into force, MP monitoring in rivers is still not included in the Water Framework Directive, although this is expected in the near future. Nevertheless, EU is already supporting the development of MP monitoring methods in riverine environments through research projects such as AQUATIC PLASTIC (AQPLA).

An important objective of the AQPLA project is to develop cost-effective methods for estimating MP contamination in rivers. To achieve this, IWRS has conducted pilot monitoring campaigns along the Sava River. Microplastic sampling in the water column focused on two approaches: using a manta net and a water pump with a specially developed filtration system. While net sampling only covered the river surface, the pump allowed sampling at various depths. Laboratory analysis followed the guidance for monitoring of microlitter in marine environments.

Our results showed that MP is present in the Sava River. Using pump sampling, we detected a significantly higher concentration of MP, averaging 29 MP/m³, compared to the manta net method, which yielded an average concentration of only 1 MP/m³.

Both sampling methods proved effective for sampling MP in rivers, with advantages and disadvantages depending on the purpose of the sampling. Generally, sampling with the net is simpler and requires fewer resources; however, it requires additional sample preparation steps during laboratory analysis and can be more susceptible to sample contamination.

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Microplastic pollution in livestock sector

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Microplastic (MP) contamination has emerged as an escalating environmental issue, pervading diverse ecological matrices and exerting detrimental impacts on habitats and species. Beyond the presence of MPs, the associated plasticizers and adsorbed chemical contaminants may elicit toxicological responses in exposed organisms.

To date, only a limited number of investigations have addressed the occurrence of MPs in agriculture and livestock sectors, and in derived products, while research on the potential transfer of MPs from animal products to humans remains in its infancy. The detection of MPs in milk, meat, and other animal-derived commodities underscores growing concerns regarding food safety and public health. Consequently, the scientific community highlights the urgent need for comprehensive studies to elucidate the exposure pathways, bioaccumulation dynamics, and potential risks associated with MP contamination in the food chain.

The aim of our research is to investigate MPs in the livestock sector, from animal feed, fodder and water to products for consumers, analysing all possible pollution problems in the entire supply chain. First studies on MP contamination in ruminant feeds, partial MP degradation in ruminal environments, and MP effects on fermentation and feed degradability were conducted, highlighting the need to delve deeper into the topic. Research on animal products started, especially on cheese, milk and meat. New tests and investigations are taking place to verify MP pollution and find sustainable alternatives. Finally, the creation of a start-up will allow us to provide specialized analysis and consultancy to improve the entire system, verifying the presence of microplastics and finding solutions.

Addressing MP contamination in livestock farming is crucial for protecting both animal and human health. Collaborative efforts between policymakers, researchers, and farmers are necessary for developing sustainable solutions, and reduce plastic in agriculture and food production.

Microplastics in commercial beverages: influence of packaging material

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Microplastics (MPs) are synthetic or semi-synthetic polymer particles between 1 µm and 5 mm, persistent in the environment and insoluble in water. Their small size allows systemic absorption, potentially causing health problems. This study aimed to quantify MPs in different beverages and estimate total intake, assessing also the influence of packaging material. Samples included tap water (n = 5), bottled water (n = 3), and commercial beverages—cola (n=3), lemon soda (n=2), beer (n=2), and wine (n=3)—from glass, plastic, can, and carton containers. The methodology consists of removing organic matter by alkaline and enzymatic digestion, followed by oxidation with hydrogen peroxide. MPs are then isolated by vacuum filtration and characterized under a stereomicroscope to determine their morphology and color. Polymer composition is determined by FTIR and Raman spectroscopy using in-house and commercial libraries.

Results showed that bottled water contained higher MP concentrations than tap water. Among beverages, cola soft drinks had the highest MP content, followed by beer and lemon soda, while wine had lower levels. Beverages in plastic containers exhibited the lowest MP concentrations, and canned drinks the highest, suggesting that packaging or storage may contribute to contamination. Using average per capita beverage consumption in Spain, annual dietary intake of MPs was estimated, with bottled water, beer, and cola soft drinks representing the most significant sources (678, 357, and 245 MPs/L, respectively). These results align with previous research and provide a comparative profile across alcoholic and non-alcoholic beverages and packaging types. The study confirms the widespread presence of MPs in commonly consumed beverages, with variation depending on beverage type and packaging. Findings suggest that beverage consumption is a relevant and previously underestimated route of MP exposure, highlighting the need for monitoring, improved packaging practices, and further research on sources and long-term effects of dietary MPs consumption.

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First study on the potential impact of plastic greenhouse environments on airborne microplastics presence

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The province of Almería (Spain) hosts the world’s largest concentration of plastic-covered greenhouses. These structures require substantial use of synthetic materials (e.g., mulching film, irrigation pipes), resulting in large volumes of plastic waste. Despite this, little is known about the possible contribution of these agricultural systems to airborne MP contamination.

This study aimed to assess the presence of airborne MPs in three contrasting environments: urban areas, surroundings of greenhouses, and a protected natural area. For this purpose, a portable active air sampling device was developed and validated to collect and quantify MPs/m³ and to characterize them in terms of morphology, colour, and polymer type.

Air concentrations differed systematically among environments. Urban sites showed the highest MP levels (~35 MPs/m³), followed by areas near greenhouses (~25 MPs/m³), while significantly lower levels were detected in the natural protected area (~15 MPs/m³). Fibres represented the dominant morphology across all sites, indicating likely sources related to synthetic textiles. Colour patterns varied by setting: black fibres were most common in the natural area, whereas blue fibres prevailed in urban and greenhouse zones. Polymer profiling indicated polyethylene terephthalate (PET) as the predominant polymer in fibres and frequent among fragments, with polypropylene (PP) also commonly detected.

This study provides novel insights into the occurrence and composition of airborne MPs in an arid agricultural region characterized by extensive plastic use. Our portable sampler provides a practical approach for standardized, on-site MP monitoring, to ensure reproducibility and comparability across studies and to support evidence-based policies for mitigating airborne plastic pollution.

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Investigation of microfibers and microplastics in process water from spunlace nonwoven production

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Microplastic (MP) pollution has become a pressing environmental issue due to its transfer to aquatic ecosystems through wastewater discharge, posing a growing risk to environmental sustainability. The textile industry, particularly nonwoven manufacturing, is one of the key contributors to this problem. The spunlace nonwoven process stands out in this context because of its high water demand and significant wastewater generation. Although several studies have investigated microplastics originating from textile effluents and disposable products, the contribution of the spunlace nonwoven production process, characterized by intensive water use and effluent discharge, to microplastic release has not yet been examined. Considering that spunlace fabrics are widely used in disposable Fast-Moving Consumer Goods (FMCG) such as wet wipes and hygiene products, and that their production volumes are continuously increasing, understanding the microplastic dynamics at different stages of the manufacturing process is crucial for evaluating the environmental sustainability of spunlace production. This study examines the formation and characteristics of microfibers (MFs)—including both synthetic (polyester) and cellulosic (viscose and cotton) types in different stages of the process water used in a spunlace nonwoven production facility. Water and sludge samples were collected from the influent, effluent, and treatment stages of the process water system. The samples were pretreated with hydrogen peroxide (30% H₂O₂) and filtered to recover MPs and MFs. Mass- and count-based assessment and characterization analyses were performed on the particles obtained after filtration. By focusing on a previously unexamined stage of textile manufacturing, this work provides the first insights into process-related microfiber and microplastic formation in spunlace nonwoven production. The results highlight the importance of developing process and policy-level strategies to improve water reuse and wastewater management in the spunlace and nonwoven industry.

Microplastics as vectors for TBT transfer in mussel *Mytilus galloprovincialis*

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Microplastic (MP) pollution is a major global problem, particularly evident in enclosed and semi-enclosed seas such as the Mediterranean Sea. Various studies have confirmed the effects of MP on marine biota, including inflammation, neurotoxicity, and genotoxicity. Due to their ubiquitous presence in the environment and high surface-to-volume ratio, they enable adsorption and can act as vectors for the transfer of pollutants such as TBT. In this way, TBT, which is known to cause DNA damage, disrupts mitochondrial metabolism, and acts as an endocrine disruptor, persists in the water column. We investigated whether MP could serve as vector for the transfer of TBT in the mussel *Mytilus galloprovincialis* by exposing mussels to TBT and MP alone and in co-exposure.

We exposed mussels to PE spheres (size range: 10–63 µm), TBT, and to both pollutants for 21 days at the following concentrations: 50 mg/L PE MP, 0.001 mg/L TBT, and 0.02 mg TBT/g PE MP. After 7, 14, and 21 days, tissue samples were collected for analysing ETS activity, measured by the reduction capacity of iodinitrotetrazolium chloride (INT), and catalase activity. Haemolymph was collected for the comet assay to determine DNA strand breakage.

We confirmed efficient TBT adsorption on PE spheres and ingestion by mussels. TBT and DBT concentrations were higher in mussel tissue in the co-exposure group compared to mussels exposed to TBT only. We observed reduced antioxidant responses after co-exposure, while TBT alone increased catalase activity in gills after 7 days and in digestive gland after 14 days of exposure. ETS activity increased in all exposed groups, suggesting elevated energy demand. DNA damage was observed in both TBT and PE MP exposed groups, but was most pronounced under TBT only exposure, confirming its higher genotoxic potential.

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A dangerous cocktail?! Assessing the ecotoxicological threats of nano/microplastics mixed with pharmaceuticals

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Chloroquine (CQ) is an antimalarial drug that has demonstrated selective toxicity in various tumor models, although its effects on liver cancer remain underexplored. In parallel, the increasing environmental presence of micro- and nanoplastics (MNPs) has raised concerns about their potential to adsorb pharmaceuticals such as CQ, thereby modulating their bioavailability and toxicity. Given the limited understanding of MNP-pharmaceutical interactions, further eco-toxicological investigation is essential. This study aimed to assess and compare the cytotoxic effects of single and binary exposures of MNPs and CQ on HepG2 cells. Cell viability was evaluated using the MTT assay after 72 hours of exposure. MNPs were tested at concentrations ranging from 12.5 to 600 µg/mL, and CQ from 0.8 to 19.2 µg/mL. Binary mixtures were prepared using the IC₂₀ and IC₅₀ values of each compound, applying the MIXTOX model.

Results confirmed a concentration- and time-dependent cytotoxicity for CQ, with higher cell viability at lower concentrations. MPs showed a similar trend, with significant viability loss at ≥200 µg/mL, suggesting a cumulative effect. NPs induced only a modest decrease in viability across tested concentrations. Notably, combined exposure of MNPs with CQ resulted in altered cytotoxic responses, with dose-dependent variations suggesting potential interaction effects between compounds.

Consistent with MTT findings, reactive oxygen species (ROS) assays also revealed changes in oxidative stress levels at specific concentrations, indicating that the presence of MNPs may influence CQ-induced oxidative responses. These findings highlight the complex nature of MNP-pharmaceutical interactions and reinforce the need to consider mixture effects in human health risk assessments.

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Fishing gear as an emergent pollutant: microplastic release and contaminant adsorption

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Marine debris from fishing activities, particularly abandoned, lost, or otherwise discarded fishing gear (ALDFG), is accumulating in oceans worldwide, imposing several impacts on the marine environment, including habitat damage and entanglement of organisms. Beyond these direct impacts, this type of marine debris has the potential to be a source of small particles of plastic (as microplastics - MPs) due to their degradation. In addition, lost plastic nets have the capacity to adsorb hazardous chemical compounds and biological agents. However, knowledge on this dual pollution potential of ALDFG remains limited. This work evaluated the potential release of MPs and the potential adsorption of contaminants by fishing nets through two complementary experimental approaches: exposure of fishing nets to natural seawater in mesocosm conditions and in quasi-real environmental conditions (nets submerged in a Portuguese fishing harbour). In both experiments, fishing nets of different materials (of polyethylene, nylon, and biodegradable material) were immersed for 9-12 months to assess: i) MP release potential, ii) metal adsorption capacity, and iii) pathogenic agents adsorption potential. Water samples were collected monthly for MPs quantification and characterization, carried out using established protocols. Polymer identification of MPs was performed using Fourier Transform Infrared (FTIR) spectroscopy. Fishing gear fragments were also collected periodically for analysis of adsorbed metals and pathogenic agents following appropriate extraction and analytical protocols. Analyses are currently underway. Results obtained will provide critical insights into the pollution potential of ALDFG, clarifying their role as a potential threat to marine ecosystem health.

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Evaluating the impact of northwest African upwelling-derived marine litter on animal entanglement in the Canary Islands

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Marine debris, particularly that derived from fishing activities, represents a serious threat to the marine ecosystems of the Canary Islands. This study integrates a Lagrangian modeling approach with observational data to investigate the transport routes, origins, and ecological impacts of floating litter, particularly on sea turtles and cetaceans, within three Special Areas of Conservation (SACs): Tenerife, Gran Canaria, and Fuerteventura. The results indicate that the Canary Current, coastal upwelling, and mesoscale eddies play a key role in the advection and seasonal accumulation of marine debris in these regions. Entanglement was identified as the main threat to sea turtles ($\approx 45\%$ of recorded anthropogenic events), while cetaceans showed a higher incidence of bycatch and vessel-strike trauma. Gastrointestinal content analyses of juvenile sea turtles stranded in Tenerife revealed plastic ingestion in 11.9% of the examined individuals (312 turtles), dominated by filaments, sheets, and fragments. Among cetaceans necropsied in the archipelago, the presence of plastic foreign bodies was found in a notable proportion (between 6% and 8% of individuals showing debris ingestion, and up to 3% of deaths directly related to such materials), with plastic bags, ropes, and fishing gear remnants being the most frequent items. Backward trajectory simulations suggest that a significant portion of this debris originates from ports along the northwest African coast. These findings underscore the pressing need to enhance marine waste management, implement robust monitoring programs, and promote international cooperation to mitigate cross-border marine pollution.

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Clean Coast (Čista obala): 15 years of coastal clean-up and citizen science on marine litter in Slovenia

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Clean Coast (Čista obala) is a volunteer coastal clean-up initiative dedicated to marine litter awareness-raising, surveying, and cleaning of the Slovenian coastline. It began in 2009 as an NGO activity supporting the former national coastal protection service in removing macro litter from the shoreline. Over the years, it developed into a national volunteer clean-up and litter survey campaign that brings together more than 100 volunteers each year to clean the entire Slovenian coast in a single day.

From the start, the project has relied on broad collaboration with local environmental services, coastal municipalities, landscape parks, protected areas, research institutions, state authorities, schools, companies, and non-governmental organizations. It is fundamentally a citizen science initiative that enables long-term and comparable marine litter data collection through public participation.

Clean Coast is part of the International Coastal Cleanup (ICC) initiative, and all activities follow standardized beach litter survey procedures aligned with the Ocean Conservancy's ICC methodology. Plastic items consistently dominate the surveyed litter, demonstrating the persistence of macro litter and its gradual fragmentation into microplastics.

In 2022–2023, “micro Clean Coast” activities were carried out in Croatia to remove macro-, meso-, and micro-litter from selected coastal sections. With support from Ocean Conservancy, multi-day volunteer clean-ups were organized on the islands of Cres, Ilovik, and Mljet, focusing on heavily polluted and difficult-to-access areas. Volunteers manually removed even the smallest micro-litter, providing insight into the full pollution profile of remote Adriatic locations.

After more than 15 years, Clean Coast has become a national environmental event in Slovenia, combining litter surveys with public discussions, exhibitions, and workshops. It is a long-standing community tradition involving families, friends, companies, and young people. More than one third of all volunteers are typically under 17 years old, highlighting strong youth engagement and demonstrating the important role this event plays in public awareness-raising.

Acknowledgments: We thank all volunteers, partners, and supporting organizations for their long-term collaboration.

Towards reduced microplastics discharge from wastewater treatment plants

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Wastewater treatment plants (WWTPs) are a major source of microplastics (MPs) and plastics additives into the natural environment despite near 100% MPs removal rates that have been shown for the effluents. However, as for many other contaminants, it is the sewage sludge that is the ultimate sink for MPs. In countries where sewage sludge is not incinerated (e.g. Estonia) but valorised in landscaping and agriculture, significant MPs concentrations reach the environment despite the high removal efficiency in the water line.

The recently revised EU Urban Wastewater Treatment Directive (UWWTD 2024/3019) will mandate advanced “quaternary treatment” of wastewater for all WWTPs >10.000 p.e. (population equivalents) by 2045 the latest, to eliminate the broadest possible spectrum of micropollutants, incl. MPs. Furthermore, new monitoring obligations will be introduced to WWTPs, covering, among other emerging contaminants, MPs in wastewater and sewage sludge.

Since plastic pollution is ubiquitous, joint regional efforts are needed and so, two neighbouring countries, Finland and Estonia, on either side of the Gulf of Finland, started cooperating on reducing MPs discharge from WWTPs. Via specific technical pilot installations at WWTPs, our primary focus will be the sludge line where, as the major result of the common 3-year initiative, project Balt-Plast-Free, MPs discharge is expected to decrease by 50%. To achieve this target, partners from both countries will first harmonize procedures for MPs sampling and quantification for comparable MPs baseline values in WWTPs matrices. Reference polymeric particles will be used for performance assessment of the harmonized procedures. By the end of this unique cross-border effort, MPs discharge will be reduced in at least two sites and Finnish and Estonian WWTPs will be better prepared for the upcoming regulatory obligations regarding MPs.

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Pilot testing of cascade treatment system for retention and elimination of micro- and nanoplastics from wastewater treatment plant effluent

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Microplastics have emerged as persistent pollutants, posing ecological and potential human health risks once released into aquatic environments. Wastewater treatment plants (WWTPs) are recognized as key hotspots for preventing their discharge into natural water bodies. However, current treatment technologies are not specifically designed for microplastic retention, resulting in partial removal and continuous emissions to receiving waters.

Within the INSPIRE project under the EU Mission: Restore our Oceans and Waters by 2030, a pilot cascade system integrating advanced treatment technologies has been tested. The system integrates technologies of project partners WNW, DELVEC, CLERA, and KTH, coordinated by partners MINDS and UM. The system was installed at the Domžale-Kamnik WWTP (Slovenia), where wastewater was treated through multiple pilot units with the goal of evaluating its performance under real operating conditions. Samples have been analyzed by laboratories of project partners VITO and VLIZ, using harmonized analytical methods to quantify both particle counts and polymer mass.

The expected outcomes include identification of optimal technology combinations and operational parameters that maximize microplastic retention efficiency, with the end goal of total elimination of microplastics from treated water bodies. The study provides an evidence-based foundation for future implementation of advanced treatment solutions and contributes to the broader European efforts to mitigate microplastic pollution and protect aquatic ecosystems.

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Tuning nitrogen plasma treatments to reduce microplastic release from synthetic textile materials

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Microplastic (MP) pollution from synthetic textiles has emerged as a critical environmental threat. Textile-origin MPs are the most common type of MP in water sludges. This is largely caused by domestic washing, as water treatment plants cannot collect all MPs. Therefore, it is important to mitigate MPs at the source. Plasma treatment has been used in the textile industry to improve material properties such as hydrophilicity, wettability, adhesion, and others. However, its impact on MP release has not been widely studied. This study investigates the effect of low-pressure nitrogen plasma treatment on MP release from polyester-elastane blend textile material.

Low-pressure nitrogen plasma treatment with varying parameters (50W/240s; 100W/120s; 200 W/60s) was applied to three sets of textile specimens, while a fourth set served as an untreated control. Specimens were cut from a pre-washed polyester-elastane blend. After treatment, specimens were washed for five consecutive washing cycles in deionized (DI) water without detergent. Released MPs from each washing cycle were collected using a vacuum filtration system with nitrocellulose membrane filters (pore size: 0.22 μm). The MPs were quantified by weighing dried filters before and after filtration.

High and medium power plasma treatments (200W/60s; 100W/120s) significantly reduced MP release compared to low-power treatment (50W/240s) or untreated samples. All specimens released the most MPs during the first washing cycle, with release declining in following cycles. Samples treated at 100 W/120s and 200 W/60s released less total MPs across all washing cycles than the other samples. High and medium power treatments probably enhanced fiber cohesion through surface densification without over-etching, while increased fiber roughness restricted fiber movement and reduced breakage. Low-power treatment produced insufficient modifications, and the increased roughness was not sufficient to reduce fiber mobility. These findings suggest that optimized plasma treatments could mitigate MPs at the source while improving textile material properties.

Are wastewater treatment plants efficient at removing microplastics? – A novel analytical technique to analyze microplastics in complex matrices

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Wastewater treatment plants (WWTPs) can remove more than 90% of the microplastics (MPs) entering the water line. However, are they truly being eliminated? The answer is no. Over 60% of the microplastics become trapped in the sludge, which is later applied to agricultural fields, reintroducing these particles into the environment.

Currently, no standardized methods exist for quantifying MPs in organic-rich matrices, such as sewage sludge and wastewater. This makes it difficult to compare results with other common pollutants, which are typically expressed in terms of mass concentration ($\text{mg}\cdot\text{L}^{-1}$).

To address this limitation, Captoplastic S.L. has developed an analytical procedure to quantify MPs concentrations in milligrams per gram of dewatered sludge ($\text{mg}\cdot\text{gdw}^{-1}$) or milligrams per liter ($\text{mg}\cdot\text{L}^{-1}$). This method uses a capture material that interacts with MPs to form magnetic aggregates, which can then be separated using an external magnetic field. A subsequent intensified oxidation step is applied to degrade non-plastic organic matter, enabling accurate MPs quantification and further identification via FTIR spectroscopy.

This study examines how MPs are distributed within a WWTP, both in the water line and the sludge line. It also presents analytical techniques for quantifying MPs in different matrices, such as wastewater and sewage sludge.

Furthermore, we evaluate potential technologies that can be implemented in WWTPs to prevent MPs from reaching the environment.

Arbuscular mycorrhizal fungi improve treatment performance and vegetative resilience in constructed wetlands exposed to microplastics

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Microplastics are increasingly present in municipal wastewater and wastewater treatment plant effluent, prompting the use of constructed wetlands (CWs) for additional treatment. Enhancing CWs with arbuscular mycorrhizal fungi (AMF), known to aid nutrient removal and alleviate plant pollution stress, is gaining interest. This study is the first to examine the influence of two microplastic polymers (polyethylene microspheres and polyester microfibers) at concentrations of 0.1 and 1 mg/L on nutrient removal, plant health, and microbial composition in AMF-inoculated CWs. The results indicate that AMF inoculation combined with microplastic treatments significantly enhances nutrient removal in wetlands, achieving a 45.7% increase in total nitrogen removal and a 25.3% increase in phosphate removal. The effects of microplastics on plant health vary depending on the inoculation status, with an increase in lipid peroxidation ($73.4\% \pm 25.4$), and a decrease in the effective quantum yield of PSII ($13.4\% \pm 5$) observed in all treatments. High concentrations of polyester microfibers significantly altered the microbial community, increasing AMF colonization frequency and microbial richness, decreasing evenness and the abundance of denitrifying genera, and creating distinct clusters in beta diversity analysis. AMF inoculation maintained higher species richness and evenness, contributing to the resilience of CWs to microplastic pollution. Overall, AMF-inoculated wetlands and plants showed superior treatment performance, highlighting the successful bio-augmentation potential of this approach.

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Remediation of microplastic pollution by plasma treatment

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Microplastic pollution poses a significant threat to ecosystems and human health. In this study, a low-power non-thermal plasma treatment was employed to degrade polyethylene, polypropylene, and polystyrene microplastics. The effects of plasma irradiation on microplastics were characterized using scanning electron microscopy (SEM), contact angle (CA) analysis, attenuated total reflection infrared spectroscopy (ATR-IR), X-ray photoelectron spectroscopy (XPS), and thermogravimetric/differential scanning calorimetry (TGA/DSC). Results showed that over 95% mass loss was achieved for all microplastic types after less than ten minutes of treatment. These findings demonstrate that plasma treatment is a clean, energy-efficient, and environmentally friendly technology for microplastic remediation in water.

Influence of physical properties on the photocatalytic degradation of LDPE mulch films

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Agricultural films, particularly made of LDPE, are widely applied in agriculture for greenhouses and mulching. Once LDPE films are introduced into the environment, they can break down into smaller plastic debris and, over time, into microplastics (<5 mm) due to aging and degradation processes in farmlands. Recently, agricultural plastic waste has become an increasing environmental challenge worldwide, with annual generation in Europe exceeding 1.3 million tonnes. While mechanical reprocessing remains cost-effective (€300–€600 per ton) for clean, uniform plastics, it is limited by soil-contaminated plastics. Therefore, greater attention should be directed toward advanced oxidation technologies to reduce microplastic pollution.

This study aims to investigate the link between physical properties and LDPE film photocatalytic degradation. The photocatalytic tests were carried out in an aqueous medium in the presence of Ag-TiO₂ catalyst. LDPE films with two of the most used colors (black and transparent) and in sizes of 1x1 mm and 3x3 mm were studied. The post-degradation analysis involved multiple analytical tools, including mass reduction, ATR-FTIR analysis, SEM imaging, and a ROS quenching test, to understand the degradation pathways and mechanisms.

The results indicated varying mass loss across the studied LDPE films, with the highest mass loss of 9.88% observed in black-colored LDPE films (1x1 mm) after 16 hours of UV exposure. SEM imaging confirmed extensive surface degradation of black LDPE films (1x1 mm), with wrinkles, cracks, and deep pits, suggesting organic volatilization and chain scission. Analysis of the chemical structure showed the formation of oxygen-containing and vinyl groups. The quenching test for ROS detection revealed that hydroxyl radicals and superoxide anions were the predominant reactive species in the Ag-TiO₂-driven photocatalytic reaction system. These results enhance understanding of the link between physical properties and photocatalytic LDPE degradation, thereby contributing to the development of advanced technologies for mitigating microplastic pollution.

Microplastics: from detection to degradation

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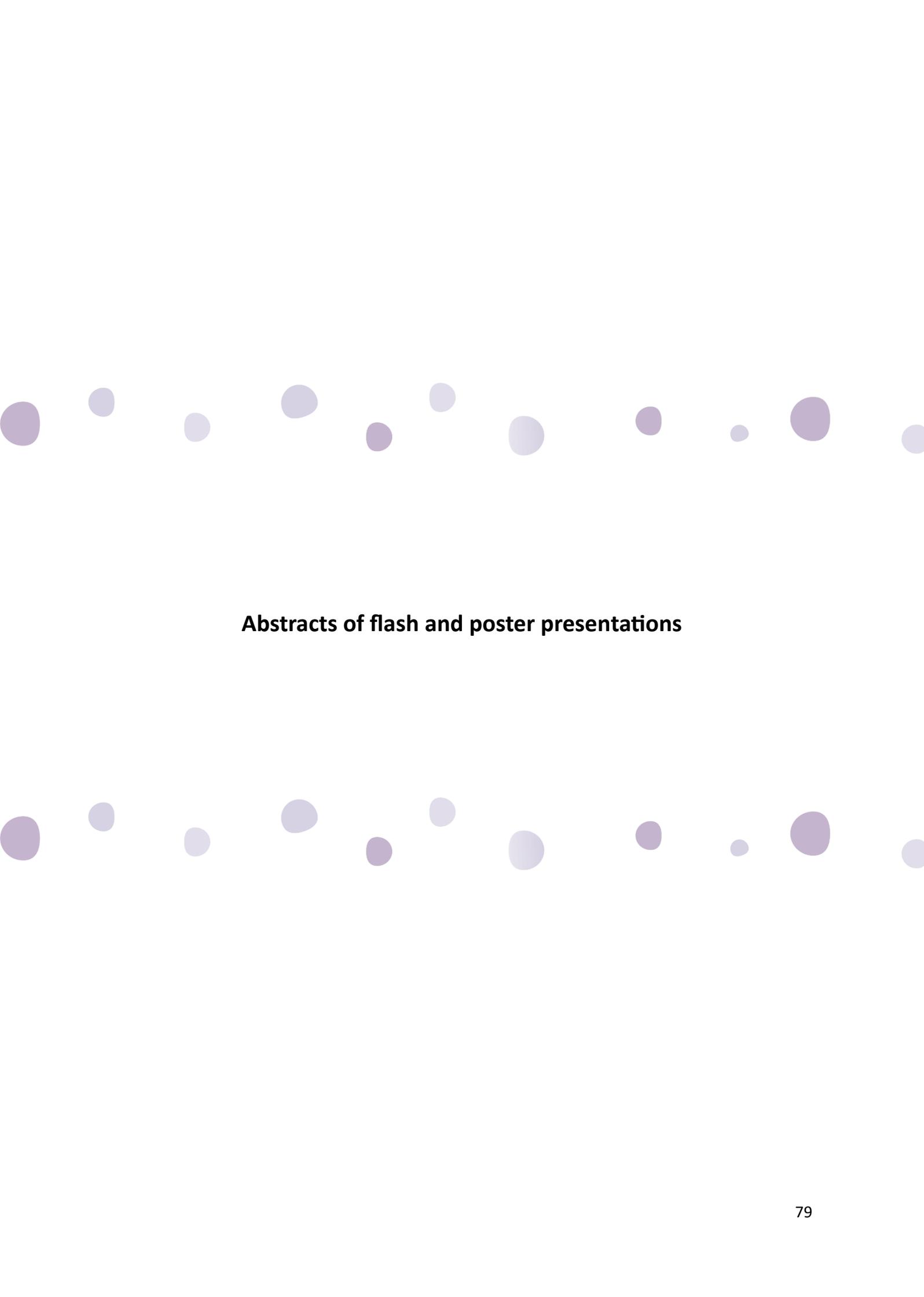
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Global plastic production has risen exponentially since the 1950s, reaching 400 million tonnes per year. A large proportion of this material eventually enters the environment, where it persists and fragments into microplastics that remain in ecosystems for long periods. Despite the growing awareness of their impact, no globally feasible solution for microplastic removal currently exists. Photocatalytic micromotors have therefore been identified as a promising approach, as they are capable of actively collecting and degrading microplastics through light-driven catalytic processes.

In this study, Pacman-shaped TiO₂ micromotors were employed for the photocatalytic degradation of polystyrene (PS) microspheres. These asymmetric particles exhibit autonomous motion under UV illumination and hydrogen peroxide as the fuel, simultaneously collecting and photodegrading microplastics. Degradation was confirmed through changes in particle size and morphology, demonstrating the dual functionality of collection and catalytic breakdown. A major challenge in microplastic research is the tracking and characterisation of irregularly shaped, heterogeneous particles produced by natural degradation. To address this, a method was developed using cryomilling of plastic samples to produce particles with varied shapes and sizes. The resulting materials were analysed using optical microscopy, and size distributions and shape descriptors were obtained through image analysis.

Current work focuses on polyethylene terephthalate samples aged under UV irradiation and in seawater, to investigate how environmental exposure affects their physicochemical properties and degradation behaviour. These combined approaches contribute to a better understanding of microplastic transformation and support the development of sustainable active-matter-based degradation systems.



Abstracts of flash and poster presentations

True-to-life microplastics: bridging laboratory and environmental relevance

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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 us 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, advanced Raman techniques, 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.

Overall, these true-to-life EPS-MNPs represent a valuable resource for realistic ecotoxicological testing and improved risk assessment. Their environmentally relevant characteristics make them suitable for the development of harmonized experimental protocols and for studies on degradation pathways, contaminant sorption, and trophic transfer.

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Exploring the potential of magnetically modified microplastics

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Tracking and quantifying microplastics in complex environmental matrices remain major analytical challenge due to their small size, heterogeneity, and diverse physicochemical properties. Magnetically modified microplastics could be an alternative test material, potentially simplifying some of the challenges faced in experimental studies.

We investigated the potential use of magnetically modified polyethylene, polypropylene, polyethylene terephthalate, and polyvinyl chloride microplastics. Microplastics were first produced by cryogenic milling and were then modified with surface deposition of iron oxide particles. The success of magnetic modification was evaluated by the determination of the iron content (1.85-2.82%), surface analysis, and by the iron leaching test at different pH levels. Results showed that the magnetically modified particles are stable in neutral pH and thus suitable for environmental studies. The potential toxicity of both magnetically modified and pristine particles was tested using duckweed *Lemna minor*. No significant differences in ecotoxicity between pristine and magnetically modified microplastics were observed. Recoveries from aqueous medium were high reaching close to 100% after 10 cycles. Similarly, there were high recovery rates (between 87 and 99%) when microplastics were sampled in sediment. However, the recovery rates from different soils were low in comparison to other matrices, averaging below 15%.

In conclusion, magnetically modified microplastics could be used as novel test materials in environmental microplastic research but within a limited set of parameters.

Synthesis of standardized core–shell nanoplastics for environmental and toxicological research

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There is a critical need for standardized nanoparticles in micro-nanoplastics (MNPs) research to ensure reproducibility, comparability, and reliability across studies. Two principal strategies for generating MNPs are the top-down and bottom-up approaches. The top-down method, involving mechanical fragmentation or degradation of bulk plastics, mimics environmental aging but often produces heterogeneous particles with broad size distributions and undefined surface chemistries. In contrast, the bottom-up approach produces nanoparticles from molecular precursors via chemical synthesis or polymerization techniques, offering precise control over size, shape, and surface functionality ideal for standardized toxicological studies. However, bottom-up synthesized MNPs may lack environmental relevance unless further modified. To address this, the development of core–shell architectures, such as silica core/polystyrene shell nanoparticles, provides a promising pathway by combining structural precision with tunable surface properties that mimic environmental interactions. This hybrid organic–inorganic materials enable improved control over particle morphology, surface chemistry, dispersibility, and analytical traceability. The silica core offers mechanical stability, density contrast for imaging, and the potential for isotopic or fluorescent labeling, while the polystyrene shell imparts realistic polymeric surface characteristics relevant to environmental nanoplastics. This configuration facilitates more accurate assessments in both environmental and toxicological contexts. While polystyrene is commonly used as a model nanoplastic due to its availability, it represents only a small fraction (~5%) of total plastic production. To enhance environmental relevance, our ongoing research will extend to other major polymers, including polyvinyl chloride (PVC), polypropylene (PP), polymethyl methacrylate (PMMA), and polyethylene (PE). These efforts aim to develop well-characterized, application-specific core shell nanoplastics that reflect real-world exposure scenarios and strengthen the robustness of MNPs studies.

The production of environmental micro- and nanoplastics from marine-aged plastics

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Plastic pollution in marine environments has become a critical global concern, driven by ineffective waste management. Once released into the sea, plastics undergo gradual degradation, leading to the formation of micro- and nanoplastics (MNPs). These persistent particles can interact with marine organisms, raising concerns about their potential toxicological effects. However, current research on MNPs is constrained by the lack of standardized reference materials that realistically reproduce the properties of environmentally aged particles. Existing studies generally employ pristine, commercially available polymers such as polystyrene, which do not reflect the complexity and surface aging of naturally formed particles. To address this gap, it is essential to develop representative MNP samples that mimic environmentally aged materials.

This study proposes a method for producing environmentally relevant MNPs from naturally aged plastics collected from the marine environment. Large fragments of degraded plastics were processed to obtain MNPs samples. The resulting powders were characterized using Raman and FT-IR spectroscopy, X-ray diffraction (XRD), dynamic light scattering (DLS), and scanning electron microscopy (SEM). These complementary analyses provided insights into the chemical composition, particle size distribution, morphology, and surface features of the degraded polymers.

The obtained powders realistically reproduce the characteristics of environmentally aged MNPs, providing a practical approach for generating representative reference materials for studying their environmental behaviour and potential impacts.

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

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The presenting author must be highlighted by underlining their name in the author list. Abstracts should be written in English and must not exceed 300 words. Figures, tables, and references are not permitted. The entire abstract, including the title, author list, affiliations, main text, and (if applicable) acknowledgments, should fit on a single A4 page.

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.

While it is generally considered non-toxic in its bulk form, its degradation products, such as lactic acid and micro/nanoplastics, may pose risks to aquatic ecosystems. For this reason, it's important to learn how to detect and study the different fates of microplastics in this environment. However, the huge interest in the chemical vector role of micro/nanoplastics with their fate and negative effects on the environment and human health is still under discussion and the research is still sparse due also to the difficulties of sampling MPs and NPs from the environment or producing NPs in laboratories. This work aims to modify and improve a known protocol, using ball-milling technique, for the MPs/NPs production, in terms of size and production yield, specifically focusing on PLA, since these aspects are poorly studied in this polymer. The results demonstrate the reliability of this new improved method, both enhancing their production, while avoiding any thermal and chemical degradation and morphological alterations. Future studies will focus on analyzing any enhance in the production of NPs, which will be used to toxicological exposure experiments.

Tailored synthesis of polyvinyl chloride nanoplastics by nanoprecipitation for risk assessment

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The extensive use and waste mismanagement of plastics raise concerns about potential health and environmental impacts of their degradation products, *e.g.*, micro and nanoplastics (MNP). Especially, nanoplastics (NP) pose unique challenges because their small size allows them to cross physiological barriers. However, most NP risk assessment studies lack environmental relevance, as they focus predominantly on polystyrene (PS) despite the diversity of plastic types entering the environment. This is largely due to the limited availability of representative reference NP from non-PS plastics.

Nanoprecipitation is a versatile technique to synthesize NP of different plastics by rapid mixing an organic solution of the desired polymer with an aqueous antisolvent. In this work, we focus on polyvinyl chloride (PVC) NP synthesis as a case study to learn about nanoprecipitation parameters, which is also relevant as PVC is widely used in flooring and packaging. Particle morphology and size modification was achieved by varying experimental parameters guided by colloidal chemistry principles, primarily Flory-Huggins interaction parameter influenced by *e.g.*, solvent polarity, surfactant use, and the temperature for both liquids. For instance, an increased polarity of the organic solvent produced uniform and round 83 nm PVC NP with surfactant SDS. As toxic SDS residual may complicate a proper risk assessment, SDS-free synthesis of PVC NP was also developed, with comparable particle morphology and uniformity achieved by either decreasing the organic solvent polarity (ca. 130 nm) or combining cold organic phase with hot antisolvent (ca. 113 nm). These parameters also influenced the yield of PVC NP (0.6%-63.6%).

This study demonstrates that nanoprecipitation could effectively generate model NP towards risk assessment, using PVC to highlight the possible manipulation of the nanoprecipitation outcomes by a rational parameter control. More rigorous statistic models are being explored to elucidate parameter interactions and to predict optimal settings for desired NP characteristics with considerable yield.

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Vintage by design: A UV-hydrolysis aging protocol for environmentally realistic PET microplastics

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Microplastics (MPs), commonly defined by the International Organization for Standardization (ISO) as plastic fragments smaller than 1 mm, have emerged as persistent environmental contaminants with increasing concern for both ecosystem and human health. Their ubiquity results largely from the fragmentation of larger plastic debris through environmental weathering processes, including abiotic factors such as ultraviolet (UV) radiation, mechanical abrasion, and hydrolysis. However, the lack of environmentally representative aged microplastic test materials hampers the reliability and comparability of experimental studies investigating their fate, toxicity, and potential remediation.

In this work, we developed and critically assessed a controlled aging protocol tailored for polyethylene terephthalate (PET), one of the most widespread polymers in aquatic environments. The method integrates UV-induced photooxidation and hydrolytic degradation to simulate realistic environmental aging while maintaining experimental reproducibility. Three “true-to-life” PET microplastics, obtained from a bottle, a bottle made with recycled PET, and a brown food-grade PET container, produced via ultracentrifugal milling to mimic environmental fragmentation, were immersed in different aqueous matrices (Milli-Q ultrapure water, tap water, and artificial seawater) to account for the influence of ionic strength and dissolved species on the degradation kinetics. Samples were irradiated continuously for seven days and subsequently characterized using Fourier transform infrared (FTIR) spectroscopy, Laser Direct Infrared (LDIR) spectroscopy, Raman spectroscopy, and pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS).

FTIR and LDIR analyses revealed distinct spectral changes indicative of PET oxidation and chain scission, confirming the onset of photooxidative degradation. Raman spectroscopy further highlighted morphological and structural surface changes. Pyrolysis-GC-MS provided a detailed chemical fingerprint of thermally stable degradation products, enabling the identification of key oxidation intermediates and oligomeric residues formed during the aging process.

The combined analytical evidence demonstrated that UV-assisted hydrolytic aging promotes both surface oxidation and molecular depolymerization, confirming the protocol’s effectiveness in producing environmentally relevant aged PET microplastics.

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Microplastic fibers detection in laundry wastewater: an aerial quantification based method

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Microplastics (MPs) in aquatic environments occur in diverse forms, with synthetic microfibers (MFs) representing one of the most prevalent types. MFs mainly originate from the washing of synthetic textiles in household washing machines and enter the environment due to the limited removal efficiency of wastewater treatment plants (WWTPs). As a result, substantial quantities of MFs are released into surface and groundwater, contributing to widespread contamination. Addressing this issue requires the development of improved methods for detecting, quantifying, and removing MFs.

Currently, MFs are characterized using techniques such as Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FT-IR), Raman Spectroscopy, and direct statistical analyses. While these methods provide detailed information about the chemical and physical properties of samples, they are limited by high costs and time-consuming procedures (Sheikhi et al., 2024).

This study proposes a simplified and cost-effective method to quantify MFs, based on directly measuring the area they occupy on a filtration membrane. This approach provides an indirect estimation of the initial microfiber concentration in unknown samples.

The procedure involves filtering representative samples of laundry wastewater, which are diluted to concentrations that allow individual fibers to be distinguished on the filter surface. The entire filter is photographed using a high-resolution camera equipped with a macro lens to enhance visibility. The image is then converted into a binary format, displaying a black background and white fibers. An automated algorithm quantifies the white pixels corresponding to the area covered by MFs. The measured area, expressed in square millimeters and calibrated according to the image scale, is then used to derive microfiber concentrations in milligrams per liter. This is achieved through a calibration curve generated from samples with known concentrations, enabling reliable and reproducible quantification.

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Mapping of sewage-derived, antibiotic-resistant microbes potentially involved in microplastic colonization in a Hungarian surface water body

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Municipal wastewater discharge is one of the main sources of surface water pollution, releasing physical, chemical, and biological contaminants - including microplastics, antibiotics, and pathogenic microorganisms - into aquatic environments. Microplastics can serve as abiotic surfaces for biofilm-forming microorganisms, promoting the emergence and spread of environmental antibiotic resistance, which poses a growing public health risk.

This research aimed to assess the extent of antibiotic pollution and the occurrence of antibiotic-resistant microorganisms in a Hungarian surface water stream, the Zagyva River, which is exposed to intensive wastewater discharge. Antibiotic resistance and biofilm-forming potential of *Pseudomonas aeruginosa*, an important opportunistic pathogen, were the focus of our research. Sampling was conducted in the summer of 2022 at three sections along the Zagyva River, with three points per site (upstream, at, and downstream of wastewater treatment plant inlets). Physicochemical water parameters were recorded, antibiotic residues quantified, and the frequency and diversity of colistin- and carbapenem-resistant microorganisms and *P. aeruginosa* were examined. Results indicated a close relationship between wastewater discharge and both the abundance and composition of resistant microorganisms, as well as the detectability of *P. aeruginosa*. Based on the ten antibiotic substances tested, *P. aeruginosa* strains and a *Klebsiella pneumoniae* isolate were generally antibiotic-sensitive, but their environmental presence requires further study. All examined isolates formed biofilms on polystyrene, supporting their potential role in microplastic colonization.

In January 2025, the European Union introduced a directive requiring the fourth stage of wastewater treatment, designed to remove microcomponents more effectively. The results of this study provide valuable insights to support the practical implementation of these new regulations and improve future wastewater management strategies.

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Seasonal dynamics and ecological risk evaluation of microplastics in the Cauvery River, Tamil Nadu, India

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Microplastics (MPs) have emerged as a major contaminant in freshwater environments, raising global concern due to their persistence, ecological impacts, and potential for long-distance transport. This study examines the spatial and seasonal variations, morphological features, polymer composition, and ecological risks of MPs in surface waters from 19 sampling stations along the Cauvery River, Tamil Nadu, India, during the dry (February) and wet (November) seasons. MP concentrations varied between 0.52 and 6.16 particles per liter, with higher levels observed during the wet season, highlighting the influence of hydrological conditions on MP distribution. Five morphological types; fibers, fragments, films, pellets, and beads were detected, with fibers constituting the most dominant form. Particle sizes ranged from 100 μm to 5000 μm , with the 500–1000 μm fraction being the most frequent. Scanning electron microscopy revealed signs of physical degradation such as surface cracking, pitting, and fibril formation. Polymer identification using micro-FTIR, Raman spectroscopy, and pyrolysis GC–MS indicated the presence of polyethylene (PE), polyethylene terephthalate (PET), polystyrene (PS), and polyamide (PA). The polymer hazard index (PHI) values ranged from 20.2 to 29.65, classifying all sampling sites as moderate risk (Class III). Comparison with other national and international freshwater systems suggests that MP contamination in the Cauvery River is predominantly driven by urban runoff, industrial effluents, and agricultural inputs. The findings highlight the importance of region-specific monitoring and management measures to mitigate microplastic contamination in riverine ecosystems.

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

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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 analyzed 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, which reproduces the sliding phenomenon under controlled snow temperature and speed conditions.

Samples from both contexts undergo the same extraction procedure before being analyzed by means of vibrational spectroscopy techniques. The first analysis is carried out using a Fourier-transform infrared micro-spectrometer 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.

The method works for samples from 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.

Detection of PET microplastics in soils using thermoanalytical methods

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In recent years, microplastics (MPs), tiny plastic particles formed by the degradation of larger plastic products, have become one of the most discussed environmental issues of our time. These plastic particles, typically smaller than 1 mm, are among the most common and persistent environmental contaminants. Their presence in soil is particularly significant because soil is a crucial medium for agriculture, nutrient cycling, and ecological balance.

Previous studies have focused on investigating the fate of microplastics in soil and their impact on the physical, chemical, and biological properties of soil. Various methods have been used to demonstrate that microplastics do not behave inertly after soil contamination and can affect abiotic (e.g., water retention, aggregation, and thermal stability) as well as biotic properties of soil (such as enzyme activity, respiration, and nitrogen content). It has also been shown that microplastics in soil can be affected by the soil environment itself and, under the action of physical, chemical, and biological processes, may gradually be altered or partially degraded.

In this study, thermoanalytical methods (TGA, TGA-MS, and Py-MS) were tested to evaluate their applicability for the detection and quantification of microplastics in different types of agricultural soils. The obtained results enabled the monitoring of the loss and transformation of microplastics during incubation and contributed to expanding knowledge about their stability and behavior in the soil environment.

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A new approach to QA/QC in particle-based microplastic analysis using deuterated polymers

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Accurate particle-based microplastic analysis remains methodologically challenging. Particle loss during multi-step sample preparation, contamination risks, and the lack of suitable internal standards often lead to inconsistent results. Quality assurance (QA) and quality control (QC) procedures are essential, yet widely lacking in standardized implementation. Traditional control materials—such as dyed or fluorescent particles or beads—often deviate in shape, density, or spectral properties from environmental microplastics, thereby limiting their analytical value.

We present a new strategy using deuterated polymers as internal standards for QA/QC in particle-based microplastic analysis. These polymers are synthesized from fully isotopically labeled monomers and followed by a cryogenic milling and sieving process, exhibiting the same physical behavior as their non-deuterated analogs. However, they show distinct spectral signatures in both FTIR and Raman spectroscopy due to characteristic CD (C–Deuterium) vibrations, enabling clear differentiation from environmental polymers.

A defined number of deuterated fragments can be added directly to environmental samples via an already established formation of potassium bromide pellets with FTIR-quantification, allowing for automated recovery rate calculations, contamination detection, and workflow validation—without interfering with the analytical process. This combination allows for a very exact spiking process, resulting in highly accurate QA/QC results.

This approach offers a robust and readily implementable QC solution, easily adaptable to existing FTIR- and Raman-based workflows. By integrating such standards, microplastic analysis becomes more reproducible, transparent, and suitable for long-term monitoring and regulatory use.

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Assessing recovery and method performance for microplastic detection in drinking water using custom-made spike particles

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In response to the emerging problem of microplastics in drinking water, the European Union has introduced a Delegated Decision specifying requirements for the monitoring and quantification of microplastics (MPs), establishing a framework for harmonized detection and reporting. However, the experimental validation of analytical methods remains a significant challenge, particularly in achieving and reporting reliable particle recovery. Addressing these challenges is essential to ensure method comparability, data reliability, and regulatory compliance across laboratories.

In this work, we introduce a novel, custom-made deuterated particle standard that can be spiked into filter-cascade filtration systems to assess recovery in microplastic analysis of drinking water. This reference standard exhibits physicochemical properties highly comparable to those of the priority microplastic polymers yet features a distinct spectral fingerprint. This enables detection and identification without interference from microplastics already present in the sample matrix.

To test our particle standard, we performed four filter-cascade filtrations of 1000 liters each of tap water, assessing the recovery of our custom spike particles. Particle detection and analysis were conducted using quantum-cascade infrared (QCL-IR) imaging in the wavenumber range of 1800–975 cm⁻¹.

Our approach, combining custom-designed spike particles with standardized analytical protocols, is expected to clarify critical aspects of method recovery and validation, supporting the implementation of the EU Delegated Decision and informing best practices for microplastic detection in drinking water.

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Interpreting microplastic pollution as a reflection of water quality degradation in highly sediment urban river

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Microplastics (MPs) are emerging indicators of anthropogenic pressure and declining river water quality. This study investigates the relationship between microplastic abundance and key physico-chemical parameters of the Yamuna River to understand how water chemistry influences MP distribution along the Delhi stretch. Water samples were analyzed for pH, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), and salinity, and correlations were established using Pearson analysis. Strong negative correlations between pH and both conductivity ($r = -0.99$) and TDS ($r = -0.99$) indicate that acidic conditions are associated with elevated ionic concentrations, likely driven by industrial discharges and urban runoff. A positive correlation between pH and DO ($r = 0.88$) reflects relatively cleaner, photosynthetically active zones. Microplastic abundance correlated positively with conductivity ($r = 0.95$) and TDS ($r = 0.94$), and negatively with pH ($r = -0.96$) and DO ($r = -0.81$), suggesting greater accumulation in low-oxygen, high-ionic-strength waters. A moderate positive correlation with salinity ($r = 0.68$) further indicates enhanced deposition in sediment-rich zones. Overall, the study highlights that microplastic contamination is strongly influenced by hydrochemical dynamics and can serve as a reliable indicator of ecosystem degradation, emphasizing the need for integrated monitoring approaches for effective river restoration.

SERS detection of environmental nanoplastics by using customized plasmonic nanostructured substrates

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Nanoplastics (NPs) have become a global concern in recent years due to their widespread occurrence in the environment and the potential risks associated to their presence in the aquatic and terrestrial ecosystems. Consequently, there is a strong demand for improved analytical methods that enable reliable detection, quantification, and monitoring of NPs. One of the main challenges in studying NPs lies in their extremely small size (below 1 μm). Environmental NPs present additional difficulties due to their diverse composition and contamination. Moreover, beyond their non-uniform size and shape, prolonged exposure to various environmental factors can further alter their physical and chemical characteristics, making accurate identification and quantification even more challenging. In this regard, surface-enhanced Raman scattering (SERS) spectroscopy has attracted increasing interest as a promising approach for NPs detection, both for standard and environmental NPs. In this study, we developed a SERS-based method for detecting environmental nanoplastics. SERS-active substrates were fabricated using colloidal and soft lithography, and their optical response and morphology were characterized. The enhancement capability of the substrates was first evaluated with standard nanoplastics and subsequently applied to environmental nanoplastics. This work highlights the relationship between the substrate morphology and nanoplastics properties and demonstrates the potential of customized SERS substrates for the detection of environmental nanoplastics.

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Developed and optimization of an analytical protocol for quantifying fine microplastics in greenhouse agricultural soils

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Intensive greenhouse farming, particularly in regions such as Almería (Spain), which boasts Europe's highest concentration of plastic-covered cultivation, has raised serious worries about soil contamination by plastic debris.

First, we improved an oil-assisted, density-based workflow by testing two inorganic salt solutions (NaCl and CaCl₂) and two oxidative reagents (Na₂S₂O₈ and Fenton's reagent) to maximise recovery while limiting matrix interferences. Second, we evaluated a non-ionic surfactant approach via cloud point extraction (CPE) as a solvent-saving alternative. Method performance was assessed with MPs spanning multiple polymers (PE, PP, PET, PBAT, PLA), size and shapes to evaluate the impact on the extraction efficiency based on their characteristics.

The final analytical approach achieved recovery rates exceeding 75% for all polymers. Applied to greenhouse-area soils from Almería, measured MP loads ranged from 1,100 to 8,500 particles kg⁻¹ (mean \approx 3,497 items kg⁻¹). Fragments dominated the assemblage (64%), with most particles between 100–250 μ m. Polymer profiling showed polypropylene as most prevalent (71%), followed by PET (14%) and PE (7%).

These results provide a detailed picture of MP contamination in intensively managed and plastic-covered agroecosystems. To our knowledge, this is the first comprehensive chemical and morphological characterisation of MPs in agricultural soils from plastic-covered greenhouses in southeastern Europe. The proposed protocol offers a practical basis for inter-study comparability and for future standardisation efforts in soil MP monitoring.

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Identification of micro- and nanoplastics in Adriatic aquaculture waters using Raman and SERS spectroscopy

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Micro- and nanoplastics (MNP) are emerging pollutants of increasing concern in marine aquaculture environments. These particles accumulate in bivalves and transfer through the food chain, ultimately reaching us through seafood consumption. This study investigates the presence and composition of MNPs in coastal Adriatic waters used for oyster cultivation, aiming to identify potential external contamination sources and evaluate the exposure of aquaculture systems.

Water samples were filtered through a column of meshes with pore sizes of 500, 250, 100, 50 and 20 µm. Retained microplastics were analyzed by Raman spectroscopy, while nanoplastics in the filtrated water were detected using surface-enhanced Raman scattering (SERS) with silver nanoparticles (AgNP). From microplastics results, the corresponding concentration is estimated to be around 10 particles/L. The dominant polymer is polyethylene (PE), followed by blue/violet pigments PB15, PB63, PV3 and smaller proportions of PET, PP and other pigments (PV1, PG7). Nanoplastic analysis revealed the dominance of PET and PP (12 times lower) with PB63 as the most abundant pigment at the nanoscale.

These findings demonstrate that Adriatic aquaculture waters are contaminated with micro- and nanoplastics dominated by common consumer and packaging polymers. The detection of PP and, especially, PB15 indicates that aquaculture ropes - composed of polypropylene and colored with phthalocyanine pigment PB15 - may represent a direct local source of contamination. This highlights the problem of using plastic materials within aquaculture infrastructure and the importance of water quality in shellfish production.

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MikAlp - Analysis of micro- and nanoplastics in complex water matrices: knowledge and analytical method transfer from academia to industry

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Micro- and nanoplastic (MNP) pollution is not just an urban problem but MNP have also been detected in rural areas such as the Alpine region. The sources of these pollutants are diverse and range from the decomposition of larger plastic waste to synthetic fibers released from clothing and textiles or tire abrasion. Microplastics, defined as plastic particles with a size of 1 µm to 5 mm, along with even smaller nanoplastic particles (< 1 µm), find their way into our ecosystems and water sources, and could ultimately affect human health. While the European Commission as well as standardization bodies like DIN and ISO have already published guidelines for sampling, preparation and analysis of microplastics in environmental and drinking water samples, robust analytical workflows for the characterization and quantification of nanoplastics are still missing. Within the INTERREG-funded MikAlp project we work on specific, effective and easy-to-use analytical strategies for MNP characterization in accordance with existing guidelines aiming at an adoption and implementation in an industrial environment.

This poster gives an overview of the overall ambition of the MikAlp project covering the preparation, characterization, and application of microplastic representative test materials as KBr pellets containing a defined number of particles (PS beads from 5-100 µm, polydisperse LDPE and PVC fragments) as well as the development of multi-detector field-flow fractionation methods for the size-resolved characterization of nanoplastic particles < 1 µm. Furthermore, Stakeholder engagement in the form of dedicated questionnaires and workshops is another central aspect of the MikAlp project ensuring that the development of analytical workflows is in line with regulatory and industrial needs.

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Microplastics in Polish freshwater ecosystems: present insights and research challenges

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This review provides the first comprehensive synthesis of available data on MP contamination in Polish freshwater ecosystems. The analysis of 22 studies published up to the end of 2024 reveals significant gaps in current MPs research. Despite the increasing number of studies from 2017 (first publication on MP in Polish freshwaters), the focus remains heavily biased toward water samples (73%), with sediments (14%) and shoreline sediments (9%) considerably underrepresented. Notably, only 4% of the studies examined both water and bottom sediments together. MP water contamination has been confirmed in lakes (av. 591 MP/m³), rivers (av. 17,860 MP/m³) and dam reservoirs, with the highest average concentration in rivers (17,860 MP/m³). In studies on MP contamination of bottom sediments in freshwater bodies in Poland, the highest concentrations were recorded in dam reservoirs (av. 65,833 MP/kg d.m.), followed by rivers (av. 3,169 MP/kg d.m.), with the lowest values observed in lakes (av. 11 MP/kg d.m.). The results demonstrate high variability in MP concentrations and highlight the strong influence of catchment characteristics, urbanisation, tourism, and wastewater treatment infrastructure. The lack of standardised methodologies for sampling, extraction, and particle classification presents a major obstacle to cross-study comparisons. Moreover, the limited number of studies with polymer identification significantly constrains our understanding of the sources of MPs and their potential risk. The current state of knowledge reveals a significant spatial imbalance in research on MPs in Polish surface waters—some regions have been thoroughly studied, while others remain virtually unexplored. These findings highlight the urgent need for more comprehensive and spatially representative investigations. Incorporating MP monitoring into national environmental programs would support evidence-based policymaking and contribute to EU-wide efforts to protect aquatic ecosystems from plastic pollution.

Microplastic detection using portable raman spectroscopy: a review of developments in environmental monitoring

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Microplastics (MPs), defined as plastic particles typically smaller than 5 mm, originate from both primary and secondary sources. Primary MPs include microbeads in personal care products and industrial plastic pellets, whereas secondary MPs arise from the fragmentation of larger plastics and from microfibers released during washing of synthetic textiles. The widespread occurrence of MPs in ecosystems and the food chain has become a major environmental concern, highlighting the need for reliable detection methods. Traditional laboratory-based techniques, such as pyrolysis–gas chromatography–mass spectrometry (Py-GC-MS), scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), and Raman spectroscopy, require extensive sample collection, transport, and preparation prior to analysis. Although these methods are accurate, they are often labor-intensive, costly, and prone to contamination. Portable Raman spectrometers, integrating compact optical systems and detectors, have therefore emerged as practical tools for rapid, field-based identification of MPs.

A systematic review of literature from Scopus and Web of Science (WOS) databases, conducted on 31 January 2025, initially retrieved 442 publications. After removing duplicates and applying two levels of screening—first based on titles and abstracts, and then on full texts—19 studies were selected that focused on the use of portable Raman spectroscopy for detecting MPs in environmental matrices. More than half of the studies employed surface-enhanced Raman spectroscopy (SERS) with portable Raman devices. Most studies were conducted without the use of a microscope, and filtration was performed prior to analysis. Notably, no study reported the use of a portable Raman device for direct analysis without prior filtration. In summary, despite the availability of portable Raman devices, their potential for real-time, on-site environmental monitoring remains underutilized. This review highlights key technical parameters, including laser wavelength, laser power, and exposure time, for the future development of portable Raman device capable of advancing in situ MPs detection without the need for filtration.

Clean Clothes, Dirty Oceans: Microplastic fiber emissions from synthetic fabrics

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The textile industry is a major contributor to microplastic pollution, responsible for up to 35% of primary microplastics released into the environment—primarily through household laundering. The Ellen MacArthur Foundation estimates that one-third of all primary microplastics in the oceans originate from textile washing, projecting 22 million tonnes of microfibers to enter marine ecosystems between 2015 and 2055. This study quantified microplastic fibers (MPFs) emissions from ten synthetic fabric samples—acrylic, polyamide, polyester, recycled polyester, and polypropylene—washed under standardized conditions. The influence of raw material, fabric properties (structure, basis weight, thickness), and washing stage (pre-wash vs. soaping/rinsing) was systematically analyzed.

Across all tests, 468–2405 MPFs were released per sample. Normalized emission rates were consistently higher during the pre-wash phase (2–17 MPF g⁻¹ min⁻¹) than during the main wash (1–9 MPF g⁻¹ min⁻¹), suggesting that omitting pre-washing could halve total emissions. Woven fabrics released up to 55% more MPFs than equivalent knitted fabrics. Yarn diameter and fabric thickness showed strong positive correlations with fiber release ($r > 0.85$). Recycled polyester emitted 31% more MPFs than virgin polyester due to polymer chain degradation during thermal-mechanical recycling.

These findings offer a robust comparative assessment of MPF shedding, emphasizing the importance of fiber type, structural characteristics, and laundering practices. The results advocate for material-conscious textile design, discourage unnecessary pre-washing, and highlight the need to improve recycling processes to mitigate microfiber release from recycled fibers. These insights inform sustainable innovation in textiles, and consumer behavior.

Evaluating filter materials and device parameters for automated microplastic quantification with raman microspectroscopy

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Understanding the environmental and health impacts of microplastics requires precise detection and measurement of (plastic) particles down to 1 μm and even below. This study introduces a methodology based on *TUM-ParticleTyper 2*, an open-source software that automates the detection, identification, quantification, and characterization of microplastics. The software employs a *Random Window Approach*, in which random sections of a filter surface are selected for measurement. Rather than imaging the entire filter surface, it performs single-point measurements on individual particles, significantly reducing analysis time.

An essential component of this approach is the selection of an appropriate filter material, which must provide strong visual contrast between the filter and plastic particles while minimizing background interference during Raman microspectroscopy. Various commercial filters, such as aluminum-coated and gold-coated polycarbonate (PC) filters, silicon filters, aluminum oxide and aluminum-coated aluminum oxide filters, were tested for their optical and spectral performance. Some aluminum-coated filters effectively minimized background noise and enable to obtain high quality spectra, though their sensitivity to pH necessitates careful sample handling. In contrast, silicon filters offered superior chemical stability, making them ideal for analyses involving harsher chemicals.

Experiments using test microplastic particles were performed to assess the Raman microspectroscopy parameters and ensure reliable results. When applied to real water samples, the method produced accurate and representative assessments of microplastic contamination.

In summary, this study emphasizes the importance of optimizing both analytical techniques and sample preparation for precise detection, identification, quantification, and characterization of small microplastics in complex matrices. The proposed methodology enhances microplastic detection capabilities and establishes a strong foundation for future investigations into microplastic pollution across various environmental and food-related contexts.

Challenges, advanced methods and perspectives in physico-chemical characterization of nanoplastics

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Nanoplastics (NPLs, plastic particles in the size range of 1 nm – 1 µm) represent an emerging topic of relevance in environmental and food science as well as in human toxicology. Although microplastics (MPs, 1 µm – 5 mm) have been recognized as a problematic particulate pollutant more than 10 years ago, NPLs have turned into focus of science and industry only recently. NPLs are expected to have greater eco-toxicological impacts as MPs, since these tiny particles may penetrate through cell membranes. This underlines the necessity for development, optimization, validation and standardization of methods suitable for the analysis of NPLs.

In this presentation challenges and perspectives in physico-chemical characterization of NPLs will be discussed. To ensure comparability between studies on NPLs, it is essential to perform inter-comparison of various methods. Here, the feasibility of different separation/fractionation methods such as field-flow fractionation (FFF) – multi-angle light scattering (MALS) for analysis of NPL size, shape, and quantification of particles will be addressed in comparison with batch methods, including dynamic light scattering (DLS) and nanoparticle tracking analysis (NTA). Additionally, the potential of FFF techniques (asymmetrical flow FFF and centrifugal FFF) combined with Raman microspectroscopy (RM) or pyrolysis gas chromatography mass spectrometry (py-GC/MS) for the chemical characterization of nanoplastics will be presented. Finally, the potential of further advanced methods (stimulated Raman scattering (SRS) microscopy, optical photothermal infrared spectroscopy (O-PTIR), etc.) will be discussed.

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Optimized digestion of human tissues for efficient microplastic analysis by μ Raman

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Microplastics (MPs) have become widespread environmental contaminants. Their documented presence in human tissues and organs mandates the development of rigorous, standardized and reliable analytical protocol for their isolation and identification.

This research is focused on the evaluation and optimization of tissue digestion techniques to maximize extraction efficiency across a large panel of human biological matrices, specifically placenta, lung, kidney, adipose tissue, muscle, spleen, liver, thyroid, and brain.

Overall, six different protocols were tested, which involved the use of a single reagent or a combination of them, such as acidic, alkaline, oxidative, and enzymatic treatments.

Most of these methods have been found to be inadequate, resulting in incomplete organic degradation or yielding turbid suspensions, which severely hampered effective filtration through fine-pore filters. Two protocols showed adequate performance: the combined digestion with proteinase K and Fenton oxidation, and the KOH single reagent protocol.

The combined protocol involved a preliminary Fenton oxidative step, followed by Proteinase K enzymatic digestion to degrade the protein components. The final step consisted of lipid removal via ethanol addition.

Replicate digestions were performed to assess the reproducibility of the protocols, and both methods proved suitable for filtration on 1 μ m glass microfiber filter and 0.2 μ m alumina filter. The combined protocol showed higher reproducibility than the KOH method.

Furthermore, recovery tests have been performed using five different types of key microplastics: LDPE, PET, PTFE, PA6, and PA12. The multiple-reagents digestion also demonstrated the preservation of polyamides, while KOH protocol failed to.

This robust approach successfully processed highly complex tissue samples making it possible to use filters of 0,2 μ m pore size.

The protocol's reproducibility and reliability enabled the successful isolation and subsequent characterization of microplastics contaminants using optical microscopy coupled with Raman spectroscopy. This methodology provides a crucial tool for advancing human microplastic exposure assessment and related toxicological studies.

Third harmonic generation imaging: A novel, label-free method for microplastic detection

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Microplastics (MPs) comprise an extremely heterogeneous group of contaminants, differing in size, shape, chemical composition, and undergoing weathering processes that change their physical and chemical properties over time. Their detection and quantification in environmental samples therefore often require labour-intensive and time-consuming procedures. Visual inspection using optical microscopy is commonly employed as initial step in MP analysis. While this approach is inexpensive and widely accessible, its reliability is highly dependent on the operator's expertise, making it prone to subjectivity and potential errors. In this study, we examined the use of third harmonic generation (THG) – a label-free, nonlinear imaging technique. In THG, the combined energy of three photons is converted into a single photon, and signals are produced at interfaces where there is a large change in the refractive index. Some of the unique advantages of THG microscopy include deep penetration into the sample, high-contrast images with improved signal-to-noise ratio, reduced sample damage due to the use of ultrafast infrared lasers. We evaluated the THG responses on four types of reference polymers: high-density polyethylene (HDPE), low-density polyethylene (LDPE), polystyrene (PS) and polypropylene (PP). To demonstrate the applicability of this technique to MPs derived from packaging products, we examined the same polymer types in the form of MPs (<50 µm), prepared by grinding the commercial plastic products. Preliminary experiments were also conducted on environmental samples such as road dust, with ongoing studies extending to various media and particle sizes to assess broader applicability. Our results indicate that THG microscopy provides a promising label-free approach for MP detection – remarkably strong and well-defined signals were obtained from both reference polymers and real MP samples, confirming the method's potential for reliable identification. Future work will focus on quantitative analysis and application on diverse environmental matrices, aiming to establish THG as a robust tool for MP detection.

Detection and quantification of microplastics in milk using fluorescence microscopy

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The widespread use of plastics has led to increasing concern about microplastic contamination in food products and the resulting human exposure. Milk is a particularly important exposure pathway due to its high consumption across all age groups and importance in nutrition. Despite this relevance, detecting small-sized microplastics in milk remains analytically challenging because of its complex organic composition.

In this work, we sought to revolutionize microplastic detection in milk through the development of a sensitive and robust methodology allowing for the unprecedented detection and quantification of microplastics as small as 1 μm in both semi-skimmed and full-fat milk. The method combines optimized sample digestion with fluorescence staining and automated microscopy-based image analysis, enabling efficient removal of organic matter while preserving microplastic particles. This workflow allows particle quantification, size distribution analysis and polymer classification. Method performance was confirmed through recovery experiments using spiked samples demonstrating high method efficiency and reproducibility.

Microplastics were detected in all five analyzed milk brands, with concentrations spanning several orders of magnitude. Polyethylene (PE), polypropylene (PP) and polystyrene (PS) were the dominant polymer types, collectively accounting for the majority of detected particles. These findings highlight the ubiquity of microplastics in milk and emphasize food products as an important exposure pathway. The developed fluorescence microscopy-based protocol provides a valuable tool for monitoring small-sized microplastics in complex food matrices and supports future efforts toward standardized and comparable microplastic measurements in food safety research.

Analyzing microplastics and heavy metals in Hungarian sewage sludge samples and their effect on opportunistic pathogen *Pseudomonas aeruginosa*

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Municipal wastewater treatment plants (WWTPs) produce a large amount of sewage sludge that is a valuable agricultural fertilizer due to its high nutrient content. At the same time, sewage sludge can be a source of contaminants, such as heavy metals, microplastics (MPs) and antibiotic-resistant bacteria (ARB) such as *Pseudomonas aeruginosa*, which can find adequate circumstances for its proliferation.

In this study, besides the measurement of microplastic and heavy metal concentrations and volumes in sludge samples collected from eight different wastewater treatment plants located in Hungary, AMR inducing effect was also evaluated. MPs were measured using two parallel analytical approach: pyrolysis gas chromatography/mass spectrometry (Py-GCMS) and Fourier-transform infrared spectroscopy (FTIR). The average values of particles per gram of dry weight (dw) were determined and the approximate volume of MPs introduced into Hungarian agricultural soils were calculated. According to our results, all sludge samples contained significant concentrations of MPs and heavy metals were also detectable. At the same time, antibiotic resistant strains of *P. aeruginosa*, a human pathogen, were detected in 88% of the samples. The concentration of heavy metals often stayed at sublethal levels for the isolated strains, creating ideal conditions for antibiotic resistance development. Moreover, by adsorbing metals and enhancing the formation of biofilms, MPs act provides adequate circumstances for the growth of ARB such as *P. aeruginosa* making sludge a hot spot for antimicrobial resistance (AMR) development.

Our results underline the importance of up-to-date regulatory frameworks and to enforce a more rigorous monitoring of sludge composition to minimize environmental pollution and the spread of AMR.

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Nano-IR spectroscopy for nanoplastics identification down to 10 nm particle size

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Nanoscale-resolved infrared imaging and spectroscopy (nano-IR) enables the chemical identification and characterization of materials down to a particle size of 10-20 nm and below [1]. The high sensitivity and 10-20 nm spatial resolution is achieved by illuminating a metallic atomic force microscopy (AFM) tip with IR radiation - creating a nanofocus below the tip. The sample is scanned below the tip to obtain simultaneous mechanical (AFM) and optical (nano-IR) images. Nano-IR spectroscopy is enabled by employing broadband or wavelength-tunable IR laser sources (such as wOPO laser covering 570-7000 cm^{-1}). The sample's local IR response is detected either via photothermal expansion forces (AFM-IR) or light scattering (nano-FTIR), depending on the measurement goals. Notably, the nano-FTIR phase and AFM-IR amplitude both closely resemble IR spectra known from FTIR absorption spectroscopy – allowing for chemical identification using established FTIR spectral databases for microplastics.

Here, we present nano-IR results obtained on nanoplastics samples, including PMMA beads of 300-600 nm diameter, degraded PET of varying shapes and sizes down to 20 nm, as well as deeply sub-micron-sized inorganic (SiO_2) and biological (amide-groups) objects measured directly on highly reflecting filters. Lastly, we introduce attocube's new IRa-SCOPE, which combines state-of-the-art nano-IR (AFM-IR & nano-FTIR) with confocal Raman and laser-based μ -IR spectroscopy (LDIR) in the same instrument. This allows for micro- to nanoplastics analysis from 100s of μm down to few 10s of nm with a sample-centric workflow and instrument automation.

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From seawater to mussels: an integrated study of microplastics and oxidative stress responses

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Microplastics (MPs), particles smaller than 1 mm, are emerging contaminants of global concern due to their persistence, ubiquity, and potential to affect aquatic organisms. Their small size enables ingestion and accumulation in tissues, causing physical and physiological disturbances and acting as vectors for other pollutants. Mussels (*Mytilus galloprovincialis*) are widely used as bioindicators as sessile filter-feeding organisms, providing insights into the accumulation and biological effects of MPs in coastal ecosystems.

This study aims to determine the occurrence, characteristics, and potential biological effects of MPs in seawater and in mussel tissues (gills and digestive glands) collected from the Šibenik Bay (Middle Adriatic Sea). A total of 1000 L of seawater was filtered through sieves to collect four size fractions (63-125 µm, 125-500 µm, 500 µm-1 mm, >1 mm). MP particles were rinsed, isolated by vacuum filtration, and analysed using ATR-FTIR. Tissues were digested using HNO₃ at 85 °C for 3.5 h followed by vacuum filtration over gold-coated polyester filters (5 µm pore size) and IR microscopic analysis. Additionally, oxidative stress biomarkers (enzymatic antioxidants - catalase, glutathione S-transferase and malondialdehyde as indicator of lipid peroxidation) were spectrophotometrically analysed in mussels to evaluate sublethal physiological responses to MP exposure.

Preliminary findings showed that different MP types were isolated from mussel tissues and seawater, although the majority of found particles were of non-plastic origin. Differences between tissues suggest variable uptake and accumulation capacities, with digestive glands showing higher MP presence than gills. Confirmed polymers in digestive glands included poly(ethylene-co-acrylic acid), polyethylene, and polyamide, while preliminary results on gills pointed to the presence of polyethylene. Fibres of different colours were the most common shapes in both mussels and water samples. Integration of MP characterization with biochemical biomarker analyses provide a comprehensive approach for understanding both the extent of environmental contamination and its biological impact on marine organisms.

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Quantitative evaluation of true-to-life nanoplastics using UV-visible spectroscopy and comparative analytical techniques

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The detection and quantification of nanoplastics in environmental samples remain major challenge in assessing their ecological and human health risks. This also applies to test materials and candidate reference materials, which often exhibit a high degree of variability in size, shape, surface chemistry, and aggregation behavior.

This study investigates the potential of UV-vis spectroscopy as a practical, fast, and accessible technique for the quantification of test nanoplastics. In particular, we generated environmentally relevant “true-to-life” polystyrene nanoplastics by means of cryogenic mechanical fragmentation followed by centrifugation steps and develop a quantification protocol based on a microvolume UV-vis spectrophotometer. The method exploits its low sample demand that allows for the measurement of scarce samples, and its non-destructive nature that enables sample recovery for subsequent analyses. To assess the reliability of this approach, we compared UV-vis measurement results with those obtained from established quantification methods, including mass-based techniques, namely pyrolysis gas chromatography mass spectrometry (Py-GC-MS) and thermogravimetric analysis (TGA), and a number-based technique, nanoparticle tracking analysis (NTA).

The comparative analysis demonstrated that UV-vis spectroscopy provides a rapid, accessible, and effective mean of quantifying nanoplastics, especially when sample volumes are limited. Despite some underestimation of nanoplastic concentrations relative to mass-based techniques, UV-vis measurement results were consistent in terms of order of magnitude, showing reliable trends across different methods.

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In search of the detection limit for PET microplastics using the TGA-IST16-GC-MS measurement system

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Due to increasing demand for plastics, global plastic production is growing rapidly, exceeding our ability to manage the resulting waste effectively and leading to the accumulation of (micro)plastics in the environment. Microplastics (MPs), especially those derived from polyethylene terephthalate (PET) and its recycled form, have emerged as persistent pollutants in both terrestrial and aquatic environments. Their widespread presence, along with their potential to adsorb toxic substances and enter food webs, has raised significant concerns for environmental integrity and human health.

Consequently, there is a strong need for standardised analytical methodologies to enable MP analysis in various environmental samples. Accurate quantification of these particles remains challenging, particularly at low concentrations where the detection limits of conventional analytical methods are reached.

This study aims to determine the detection limit for PET MPs using the TGA-IST16-GC-MS measurement system. The method involves thermogravimetric analysis (TGA) with heated interface storage for decomposition gases (IST16) by segments specified on the TGA curve, followed by gas chromatography coupled with mass spectrometry (GC-MS) to enable both qualitative and quantitative evolved gas analysis (EGA). The TGA-IST16-GC-MS measurement system is well-suited for detecting PET MPs, as it integrates thermal decomposition with efficient chemical identification. This approach allows for quantitative, polymer-specific analysis even in complex environmental samples. Establishing its detection limits is essential for assessing the technique's sensitivity, ensuring accurate quantification, and verifying its suitability for trace microplastic monitoring.

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Unveiling microplastics distribution in biological tissues: A combined μ CT and LA-ICP-MS strategy for spatial distribution and chemical characterization

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Microplastics (MPs) have become a defining environmental and biomedical concern of the 21st century. Generated from the degradation of larger plastics or directly introduced through industrial and consumer products, MPs are now detected in every environmental sphere, from oceans and soils to food chains and drinking water. Their presence has also been confirmed in living organisms, including humans, raising urgent questions about their biodistribution, persistence, and toxicological effects. Sources of exposure are diverse, encompassing seafood, food packaging, additives, and airborne particles. While evidence is mounting that MPs may accumulate in tissues and interact with biological systems, the mechanisms of their transport and long-term health implications remain undiscovered. A major barrier to progress is the lack of robust, reproducible analytical workflows capable of simultaneously resolving MPs structural localization and chemical composition in complex biological matrices.

In this poster, we introduce a multimodal analytical approach that integrates micro-computed tomography (μ CT) with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). μ CT provides high-resolution, non-invasive volumetric imaging of the tissue, enabling the identification of regions of interest where MPs are likely to accumulate. Complementarily, LA-ICP-MS delivers element-specific chemical maps, allowing retrospective confirmation of MPs by the detection of associated marker elements. By combining these modalities, our workflow enables volumetric segmentation of MPs, reconstruction of their 3D distribution, and statistical evaluation of particle size and abundance. This dual-modality approach establishes a reproducible framework for MPs detection in biological tissues, connecting both structural and chemical information. Beyond its application to simulated model tissue, the protocol offers a promising methodological foundation for future studies aimed at elucidating MPs biodistribution in humans and assessing their potential health risks.

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Tri-analytical investigation of UV-induced degradation in agricultural plastics: toward safe-and-sustainable-by-design polymers

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Poly(butylene adipate-co-terephthalate) (PBAT) and Poly(lactic acid) (PLA) are widely used as biodegradable mulch films and Polypropylene (PP) is one of the most widely reported microplastic types in agricultural soils. Understanding their photo-oxidative degradation is essential for developing materials consistent with Safe-and-Sustainable-by-Design (SSbD) principles. In this work, these microplastics underwent eight-week accelerated UV exposure (equivalent to one year in the real world) simulating Mediterranean greenhouse conditions, and analyzed via FTIR/ATR, SEM, and Py-GC/MS to correlate chemical, structural, and molecular degradation.

In PBAT, FTIR-ATR revealed an initial drop then recovery of the primary carbonyl index, while secondary carbonyl and hydroxyl indices rose; the ester band index decreased then rebounded, indicating ester cleavage plus partial recombination (controlled chain scission). SEM displayed ductile fracture with fibrils, micro-voids and pull-outs, consistent with Norrish I/II scission. Py-GC/MS showed increasing 1,6-Dioxacyclododecane-7,12-dione (CBA) and the late appearance (\geq Week 4) of but-3-en-1-yl benzoate, di(but-3-en-1-yl) adipate and di(but-3-en-1-yl) terephthalate (DBT). PLA underwent rapid photo-oxidative depolymerisation: carbonyl index exhibited a net decrease, possibly due to preferential hydrolysis of existing ester carbonyls outweighing formation of new oxidation products, hydroxyl index fluctuated but trended downward (peroxide decomposition), and ester index declined continuously. SEM showed early crack initiation, pits and brittle fracture while Py-GC/MS oligomer ratios fell strongly (tetramer/dimer 1.12 to 0.78; hexamer/dimer 0.52 to 0.19). PP experienced progressive oxidation: carbonyl rose to a Week 5 peak; hydroxyl increased continuously. PP surfaces demonstrated embrittlement and crazing-pattern formation, but no extensive fibrillation. Py-GC/MS tetramer/trimer dropped 2.04 to 0.98 with parallel higher-oligomer declines, confirming backbone scission as the dominant pathway.

Collectively, results demonstrate polymer-specific degradation dynamics: PBAT retains ductility through partial recombination, whereas PLA and PP undergo rapid chain scission leading to embrittlement. The tri-analytical workflow provides a robust framework for screening polymer stability under controlled UV exposure.

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Development of an extraction protocol for nanoplastics in agricultural soils

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Agricultural soils are becoming increasingly contaminated with nanoplastics (NPs) from widespread use of plastics in farming. Due to their nanoscale size and strong tendency to interact with soil particles through aggregation and adsorption, NPs extraction and quantification remains highly challenging. Microplastic extraction methods, like density separation, are often ineffective for NPs. Without standardized and efficient extraction techniques, accurate assessment of NPs contamination in soil remains difficult.

In this study, an extraction protocol for NPs from soil was developed using 198 nm europium-doped polystyrene nanoparticles (PS-Eu NPs). The metal-doped NPs serve as tracers in method development, enabling highly sensitive detection and accurate quantification of extraction recovery through single-particle inductively coupled plasma mass spectrometry (spICP-MS).

Two grams of soils (loamy sand, clay loam, and silty clay) were spiked with 200 µg of PS-Eu NPs (corresponding to 4.6×10^{10} particles). Extraction was carried out using 2.5 mM tetrasodium pyrophosphate. The resulting supernatant, obtained after shaking, settling, and centrifugation, was treated with 30% H₂O₂ to digest organic matter. Aliquots collected at various steps of the protocol were diluted and analysed with spICP-MS.

Preliminary results showed that soil type affected PS-Eu NPs extraction recovery. The highest recoveries were obtained from loamy sand, followed by clay loam and silty clay, for both particle number concentration (73–80%, 56–60%, and 49–50%) and mass concentration (63–72%, 52–60%, and 46–49%). spICP-MS analysis showed that Eu mass per particle remained consistent across all samples, indicating no substantial leaching or aggregation of the metal tracer. Therefore, the extraction procedure likely did not alter particle integrity.

Future research will extend the assessment of this protocol to different NP polymer types and sizes, followed by identification and quantification using pyrolysis-GC-MS. This approach will enable the development of a more consistent and comprehensive framework for measuring NPs in soils.

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Laser-Induced Breakdown Spectroscopy imaging of plastics from cave environment

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Subterranean karst environments represent unique ecosystems that are highly sensitive to external disturbances and have limited opportunities for natural recovery. Despite their isolation, these systems are increasingly impacted by one of the most pervasive pollutants of our time—plastic and microplastic particles. These particles can penetrate underground realms via surface water infiltration, wastewater inputs, and human visitation of caves. Once introduced, they may disrupt fragile trophic structures, alter microbial communities, and pose persistent risks to the hydro-geological and ecological integrity of karst systems.

The presented work focuses on the detection of plastic particles in sediment samples from the Moravian Karst in the Czech Republic. In parallel to conventional microplastic characterization techniques, we are developing an innovative analytical method based on Laser-Induced Breakdown Spectroscopy (LIBS). This method enables rapid, sensitive, and minimally destructive identification of polymeric materials in samples, without the need for lengthy separation procedures. Our experimental setup allows chemical mapping of sediment surfaces, providing spatially resolved information on the distribution of microplastic particles and their elemental composition. LIBS spectra yield characteristic elemental fingerprints, allowing reliable differentiation between organic polymers and mineral phases naturally present in cave sediments. Moreover, the approach facilitates the generation of spectral reference libraries for diverse polymer types.

Our objective is to deliver a novel monitoring tool suitable for karst environments and cave systems. The outcomes offer promise for advancing the understanding of microplastic migration into underground settings, while supporting improved conservation strategies for karst regions—critical as drinking-water reservoirs and as irreplaceable natural and cultural heritage.

Monitoring and quantification of microplastics emissions and measures to decrease microplastics pollution from Finnish and Estonian WWTPs into the Baltic Sea – project “Balt-Plast-Free”

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The “Balt-Plast-Free” project will tackle the highly relevant problem of cross-border microplastics (MPs) pollution in the Baltic Sea from Finnish and Estonian Wastewater Treatment Plants (WWTPs) - a major point source of emission. The motivation is the recently approved revision of the EU Urban Wastewater Treatment Directive (UWWTD 2024/3019) which will stepwise enforce advanced “quaternary treatment” and monitoring of MPs in urban wastewater and sludge the latest by 2045.

To assure early preparedness for this regulatory change, joint Finnish-Estonian actions will be implemented to quantify the MPs emissions from various WWTPs on both sides of the border by using jointly developed harmonized protocols for MPs analysis. Moreover, specific technical measures to reduce the MPs emissions in practice will be tested onsite at 1 Finnish and 1 Estonian WWTP.

The main result of the project is reduction in MPs emission in urban load sources such as WWTPs. The main project outputs will encompass:

- Technical measures to retain the MPs within WWTPs and significantly reduce the MPs discharge into the marine and terrestrial environment via treated effluent and sewage sludge valorisation in agriculture.
- Sampling guidebook for WWTP staff.
- Harmonized protocols for joint analysis of MPs based on know-how exchange.
- Cross-border WWTP staff training on sampling and in-situ MPs analysis using a mobile laboratory acquired through the project.
- Increased awareness of the risks from discharging MPs and hazardous additives into the environment.
- Target groups from the outputs: general public, public authorities (WWTPs), NGOs, SMEs and enterprises, scientists, students, pupils.

The novelty of the project lies in the unique collaboration between Finland and Estonia to jointly approach the MPs pollution problem in the Baltic Sea.

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Impact of biodegradable microplastics on soil quality

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Biodegradable microplastics, particularly poly-3-hydroxybutyrate (P3HB), are projected to increasingly contaminate agricultural soils via mulching films, coatings, and packaging fragmentation. Therefore, it is of great importance to understand their impact on soil quality. Our group has addressed this issue by employing pot and lab experiments spanning contrasting textures, P3HB concentrations, inoculation, and plant presence/absence. We demonstrated that P3HB acts as a highly labile carbon subsidy that stimulates microbial respiration, dehydrogenase activity, and several C- and N-cycling enzymes, while consistently suppressing crop biomass at moderate-to-high doses. Mechanistically, rapid microbial utilization of P3HB elevates soil C:N, drives nitrogen immobilization and N-mining from soil organic matter, depresses nitrate availability, and shifts microbial communities toward copiotrophic P3HB-degraders (e.g., *Actinobacteria*, *Alphaproteobacteria*) at the expense of oligotrophs and nitrifiers; fungal communities are particularly sensitive, with taxa-specific increases and declines. These processes collectively inhibit nitrification and constrain plant N supply. Evidence further indicates transient oxygen depletion during early biodegradation, favouring facultative anaerobes (e.g., *Clostridia*) and compounding nitrifier losses. Manipulation with soil texture revealed that in sand-rich, nutrient-poor matrices, stimulation of respiration and PHB-degraders is pronounced, while plant growth remains strongly curtailed. A pragmatic threshold emerges at $\geq 1\%$ (w/w) P3HB, microbial and biochemical disruptions markedly reduce plant growth despite enhancements in microbial biomass C and some indicators of soil quality, underscoring a trade-off between microbial activation and crop productivity. Residual P3HB can persist during experiments, and changes in SOM quality point to accelerated turnover of more stable SOM fractions in some soils. Therefore, our studies caution that while biodegradable microplastics can invigorate microbial functioning, they risk destabilizing nutrient stoichiometry and impairing plant performance when concentrations approach those plausible under intensive agricultural use. Management should therefore minimize P3HB loading in topsoil and consider soil texture, crop timing, and N provisioning to avoid threshold exceedance and safeguard soil–plant system performance.

Soil microbial diversity shifts in microplastic polluted compost

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Single-use plastic bags are one of the most persistent sources of plastic pollution. While biodegradable alternatives are increasingly promoted as sustainable solutions, their long-term environmental fate remains uncertain. The consequences of their fragments (microplastics, MPs) remaining after composting on the compost properties remain unclear. As bags are commonly improperly disposed on compost we investigated the effects of composted MPs derived from polyethylene, home-compostable PBAT, and industrial-compostable PBAT on the compost microbiome.

Cryo-milled microplastics were mixed with compost and incubated at 40 °C for 30 days, then mixed with Lufa 2.2 soil to achieve final microplastic concentrations of 0.15% and 1.5%. Total DNA was then isolated from this compost material. Diversity analysis of the microbial community (bacteria, archaea, and eukaryotes) were performed using high-throughput amplicon sequencing of taxonomic markers (16S rDNA, 18S rDNA, and ITS). After initial bioinformatic processing to identify the microbial diversity of each sample, alpha and beta diversity analyses were conducted. We will report on the results of these analyses, which provide valuable information on the impact of biodegradable and conventional microplastic on the complex microbiome of compost.

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Exposure of microbial consortia to microplastics

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The escalating global production of plastic polymers and the related accumulation of recalcitrant waste necessitate innovative disposal methods to complement the current practices of recycling and incineration. While microbial biodegradation offers a promising, environmentally friendly possibility, the use of single organisms is often impractical for large-scale, heterogeneous waste streams. Our study addresses this by focusing on the collective potential of microbial consortia, whose combined enzymatic activities are expected to provide a more robust and efficient means of plastic degradation.

The primary goal of this work is to establish and enrich specialized microbial communities capable of utilizing three commonly used plastic polymers: polypropylene, polyethylene, and nylon. We prepared a complex inoculum by combining environmental samples contaminated with (micro)plastic and verified plastic-degrading fungal strains. These samples were used to inoculate defined media where the three types of microplastics served as the main source of carbon.

The consortia underwent three successive periods of selective enrichment on the mixed microplastic substrates. The resulting microbial diversity of the consortia was then assessed and compared against a control (identical conditions and inoculate without microplastics) to identify organisms specifically enriched in the presence of microplastic. Diversity analyses were performed using high-throughput amplicon sequencing of taxonomic markers (bacterial and archaeal 16S rDNA, eukaryotic 18S rDNA, and fungal ITS). Bioinformatic processing, including the comparison of community composition and diversity indices, was carried out using the QIIME2 platform. We will present the results of these analyses, particularly focusing on the impact of the microplastic on the community structure of the microbial consortia and the changes in abundance of species that potentially play a role in biodegradation of plastic polymers.

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Combined effects of glyphosate and polyethylene microplastics on *Chlorella vulgaris*: Insights into algal responses and environmental risks

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Microplastic contamination has emerged as a pervasive global environmental issue, with polyethylene microplastics (PE-MPs) recognized as one of the most common synthetic particles detected in aquatic ecosystems. When occurring in aquatic environment with pesticides such as glyphosate (GLY), these pollutants represent an emerging multifactorial stressor for aquatic primary producers, whose interactive effects remain insufficiently characterized. In our study, the model green alga *Chlorella vulgaris* was used to assess the individual and joint toxic responses to GLY and PE-MPs under controlled laboratory conditions. Short-term (3-day) and chronic (7-day) exposure assays were performed using GLY concentrations ranging from 1 to 40 mg/L, applied alone or in combination with 10 mg/L PE-MPs. Median effective concentrations (EC₅₀) were determined using a four-parameter log-logistic (4PL) model. After 72 hours, EC₅₀ values were 9.77 mg/L for GLY alone and 2.31 mg/L for the GLY and PE-MP mixture, indicating a pronounced increase in toxicity during co-exposure. Combined treatments resulted in substantial reductions in chlorophyll *a*, chlorophyll *b*, and carotenoid contents up to 65% compared to controls and elevated oxidative stress indicators, including reactive oxygen species production and malondialdehyde accumulation. Increased activity of antioxidant enzymes (superoxide dismutase and catalase) reflected activation of cellular defense mechanisms. Overall, these findings demonstrate that polyethylene microplastics intensify GLY toxicity in *C. vulgaris*, potentially impairing algal health and ecosystem functioning. The study underscores the need to evaluate such interactions at environmentally relevant concentrations and across various polymer types to better understand their ecological implications.

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Introducing AWARE project: the key role of plastic in mediating ecosystem fluxes at the sediment-water interface

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Plastic pollution is increasingly recognized as a major threat to freshwater ecosystems. While toxicological effects on individual organisms are well documented, broader ecosystem-level consequences remain largely overlooked. Emerging evidence suggests that plastics may disrupt ecosystem functioning by altering fundamental fluxes of nutrients, energy, and (micro)organisms at critical interfaces, such as the sediment-water boundaries. These effects are often mediated by biofilms that colonize plastic surfaces which seem capable of competing for nutrients, sorbing contaminants and facilitating microbial exchange between compartments. Such processes have the potential to modify biogeochemical cycles and microbial community assemblies, yet the mechanisms and thresholds governing these interactions are still poorly understood. To address these gaps, the AWARE project aims to investigate the broader implications of plastic pollution on freshwater ecosystems, with a key focus on the sediment-water interface. Firstly, we will assess how plastics and their associated biofilms influence nutrient availability and planktonic community dynamics. Next, we will evaluate how biotically aged plastics modify the physicochemical properties of sediments, with implications for nutrient fluxes, microbial exchange, and kinetic energy dissipation at the water-sediment interface. By integrating controlled experiments with mechanistic insights, this research aims to reveal how plastics act as novel abiotic components of aquatic ecosystems. Understanding the mechanisms behind these processes is essential for redefining risk assessment frameworks and addressing ecological impacts associated to the ongoing plastic pollution crisis.

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Sex-dependent variations in the immune status of the terrestrial isopod *Porcellio laevis* (Crustacea, Isopoda) as a response to microplastic exposure in soil

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The immune status of an organism refers to the ability of the immune system to protect the organism against a broad range of challenges. This capacity is shaped by various intrinsic factors, including the organism's sex. In this study, we investigated whether the immune response to microplastics (MPs) in terrestrial isopod *Porcellio laevis* is sex-dependent. We hypothesised that male and female isopods would respond differently, as indicated by distinct changes in immune parameter levels. Test organisms were exposed for 14 days to two types of MPs, prepared from agricultural plastics: non-biodegradable polypropylene (PP) and biodegradable polybutylene adipate terephthalate (PBAT). Four test concentrations (0, 0.05, 0.5, and 5% w/w dry weight) of both MP types were prepared in standard agricultural Lufa 2.2 soil. We assessed animal survival and changes in body mass, followed by the analysis of selected immune parameters in the haemolymph of *P. laevis*, including total haemocyte count (THC), differential haemocyte count (DHC), haemocyte viability, and phenoloxidase (PO)-like activity. The results indicate a significant effect of sex on survival of *P. laevis* exposed to PP MPs, while in contrast, no effect was found on body mass change. Regarding immune parameters, the study revealed that both THC and (PO)-like activity were significantly influenced by sex in *P. laevis* exposed to PP MPs. Regarding PO-like activity, males exhibited significantly lower PO-like activity than females at the highest test concentration (5%, w/w). On the contrary, no sex-dependent effect was observed in the case of PBAT MPs. Overall, in addition to the effect of sex, the organisms' responses were also significantly influenced by test concentration for both types of microplastics. However, no significant interaction between sex and concentration was observed for either MP type. These findings highlight the importance of considering sex as a biological variable in MP ecotoxicological assessments.

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Effect of microplastic leachates on growth and selected physiological parameters of common buckwheat (*Fagopyrum esculentum Moench.*) in hydroponic experiment

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Plastic is one of the most widely used materials in our daily lives. However, the problem of environmental pollution caused especially by microplastics (MPs), is widely recognised. As many as 16.000 different chemicals used in the synthesis of various types of plastic were reported. Chemicals that are inherently harmful to the environment are used in production, but their use is mostly regulated. A bigger problem is posed by the byproducts released into the environment during its degradation, due to the influence of physical, chemical and biological factors – a process called leaching. The study aimed to test the effects of leachates obtained from three types of MP on the growth and physiological parameters of common buckwheat. A hydroponic experiment was set up over a period of seven weeks, using three types of cryo-milled MPs: one from conventional polyethylene and two types of biodegradable polybutylene adipate terephthalate bags, specifically home-compostable and industrial-compostable. We tested three different concentrations of each type of MP leachate: 0.01%, 0.1%, and 1%, alongside a control group. Treatments were replicated five times, with each replicate containing five plants. Shoot growth was measured weekly, while photosynthetic efficiency and transpiration rate were monitored twice during the experiment. At the end of the study, final lengths of shoots and roots were recorded, fresh and dry biomass were weighed, and photosynthetic pigments were analysed. Our results showed no differences in shoot length, photosynthetic efficiency, transpiration rate or photosynthetic pigments between the treatments. Few differences in fresh root biomass between various MP treatments were observed; however, none of these significantly differed from the control. To our best knowledge, this is the first report on the effects of the leachates of different MPs on the growth and physiology of common buckwheat, indicating that MP leachates have no adverse impact on buckwheat growth and development.

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Oxo-biodegradable low-density polyethylene: The impact of artificial weathering parameters on abiotic degradation

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Plastic pollution presents a global challenge: of the 400+ million metric tons produced annually, less than 10% has been successfully reprocessed into new materials. The properties that make plastics so invaluable—resistance to degradation, durability, and chemical stability—have also contributed to a growing environmental crisis, with plastic waste escaping recycling and accumulating in terrestrial and aquatic ecosystems. When plastic is weathered, by being exposed to sunlight, heat, and humidity, surface oxidation results in the formation of carbonyl groups, leading to polymer fragmentation and microplastics formation. In this project, the role of these parameters on the degradation of oxo-biodegradable low-density polyethylene has been studied by varying temperature, humidity, irradiation cycling, and daily irradiation duration. The level of oxidation was assessed *via* ATR-FTIR by quantification of the carbonyl index (CI). While CI is commonly used to assess the degree of abiotic degradation in polyolefins, the results presented in this poster suggest that relying on this metric alone may underestimate degradation by overlooking at other parameters. These findings highlight the complexity of abiotic fragmentation and the need for multifaceted evaluation metrics.

Comparative effects of different types of microplastics on *Salvinia auriculata*

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Microplastic pollution is a global problem which can pose a serious threat to ecological processes and environmental health. Recent studies have shown that microplastics can be absorbed and accumulated in the plants and may induce physiological, biochemical, and genetic toxic effects. Earlier studies suggest that microplastic pollution can inhibit the growth rate and reduce chlorophyll content of aquatic plants, however its impact on macrohydrophytes remains largely unknown. The aim of this study was to assess and compare the influence of different types of microplastics: pristine and aged polyethylene (PE) and pristine and aged tire wear microplastics (TW) on aquatic macrophyte *Salvinia auriculata* Aubl. Plants were exposed to microplastics at concentrations found in polluted waters (5000 particles/L) in half-strength Steinberg medium for 7 days. Control samples without microplastics, as well as samples containing wood particles (natural control) at equivalent concentration were also included. The number of leaves was recorded at the beginning and at the end of the experiment. The plants were carefully rinsed with distilled water, dried with filter paper, and weighed. Relative growth rate (RGR) was calculated based on the leaves number and the biomass changes. Chlorophyll *a* and *b* content was determined spectrophotometrically after extraction with ethyl alcohol. The results showed that microplastics influenced the chlorophyll content and the growth of *Salvinia auriculata*, however plant reaction depended on the microplastic type. The effects of TW were mostly observed on chlorophyll content, whereas PE predominantly influenced plant biomass.

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Effect of biodegradable and conventional microplastics on freshwater microcosm

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Freshwater ecosystems are increasingly threatened by microplastics, which can accumulate in organisms, disrupt physiological functions, and act as carriers of harmful substances. Although biodegradable plastics are often marketed as environmentally friendly alternatives, their degradation in aquatic environments is often slow and incomplete, allowing them to persist long enough to potentially affect aquatic life.

We studied the impact of three differently types of microplastics: polyethylene terephthalate (PET, non-biodegradable), polylactic acid (PLA, low biodegradable) and poly(3-hydroxybutyrate) (P3HB, high biodegradable), on two freshwater organisms *Daphnia magna* and *Lemna minor*. To mimic environmentally more relevant scenario, both organisms were combined in one microcosm. Over a 21-day period, two separate experiments were conducted in which the organisms were exposed to microplastics at concentrations of 10 mg/L and 100 mg/L, with particle size of less than 80 µm. The most visible effects were found in the presence of P3HB. At 10 mg/L, it stimulated and accelerated reproduction in *Daphnia magna*, while at 100 mg/L it caused mass mortality. At 10 mg/L of P3HB, *Lemna minor* had statistically significantly more fronds, longer root length and lower chlorophyll *a* content, whereas effects at 100 mg/L were minimal. Analysis done under optical microscope showed that P3HB particles even in high exposure concentrations 100 mg/L were not present in *Daphnia magna*. On the other hand, PLA and PET particles accumulated in the gut of *the organisms* at both concentrations but had minor effects on survival and reproduction.

The results indicate that the presence of microplastics can have a major effect on the aquatic ecosystems, even if they are biodegradable. Future studies should consider long term studies and critical evaluation of the biodegradable materials in aquatic environments.

Automated RAG-augmented information extraction in microplastic toxicology research

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Growing evidence from literature data indicates that exposure to microplastic (MP) and nanoplastic (NP) particles may disrupt metabolic, oxidative, and biochemical homeostasis in biological systems. However, the rapidly expanding volume of publications presents major challenges for systematic review and quantitative synthesis. To address this, we developed an automated Retrieval-Augmented Generation (RAG) pipeline for information extraction and evidence mapping from scientific literature in microplastic toxicology.

A curated dataset of peer-reviewed articles was compiled from PubMed and Google Scholar. Full-text data were encoded into semantic embeddings using the text-embedding-3 model and indexed in a FAISS vector database to enable high-precision similarity retrieval. Natural language queries were processed via a GPT-5 model connected to the vector index, allowing context-aware retrieval and structured data extraction in JSON format. Extracted variables included experimental model, polymer type, particle size, exposure dose, biological matrices, and key biochemical and oxidative stress biomarkers.

Compared to conventional prompt-based extraction, the RAG-augmented pipeline improved contextual precision, minimized hallucination frequency, and ensured full source traceability. The resulting architecture provides a scalable, reproducible, and transparent approach for automated meta-analysis in environmental health research, facilitating data integration and interpretation in emerging domains of microplastic toxicity. This methodology can be readily adapted to other domains requiring automated synthesis of complex, heterogeneous biomedical data.

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Influence of extraction conditions on microplastic detection and polymer integrity in biological matrices

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Microplastics have recently been reported in human biological samples, raising concerns about potential health risks, although conclusive evidence is still lacking. Detecting particles in complex fluids such as blood and urine requires preparation workflows that effectively remove biological material while maintaining the integrity of the polymers. This study develops and evaluates such protocols using Laser Direct Infrared spectroscopy (LDIR, Agilent 8700).

The work builds on an initial review of ethical and legal aspects of handling biological samples, followed by contamination-controlled sampling, transport, and storage procedures. For blood, oxidative (H₂O₂) and alkaline (KOH) digestion were compared. Oxidative treatment produced foaming and persistent residues that obstructed analysis, whereas alkaline digestion under controlled conditions provided reproducible filtrates suitable for spectroscopic identification. For urine, direct filtration as well as alkaline and oxidative digestion were investigated. All approaches were impeded by crystalline precipitates, most likely calcium phosphate, which masked particles on the filters and prevented reliable detection.

To further understand how extraction chemistry influences analytical performance and polymer stability, ongoing work at the University of Brescia focuses on the preparation of “true-to-life” reference microplastics (PE, PET, PS, PVC) and their physicochemical characterization using microFTIR and SEM. These controlled systems will allow systematic evaluation of possible changes in particle morphology or spectral features induced by extraction conditions and contribute to the establishment of a reference database for polymer integrity.

The combined findings aim to harmonize sample preparation workflows for biological matrices and provide a methodological framework for future validation studies, including spiking experiments and cross-laboratory comparisons.

Formation and cytotoxicity of microplastics from biodegradable materials and biocomposites

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Microplastic pollution has emerged as a significant global environmental concern, with numerous studies confirming their widespread presence in aquatic and terrestrial environments, as well as in human tissues. Biodegradable plastics were initially introduced as a sustainable alternative to conventional polymers. However, recent evidence demonstrates that these materials also undergo fragmentation, forming biodegradable microplastic particles (BioMPs) that may pose risks to both ecosystems and human health.

Most existing studies have focused on pristine biodegradable polymers, whereas commercial materials typically contain various stabilizers, antioxidants, and pigments. These additives can influence the degradation behavior of biodegradable plastics, affecting both the rate of BioMPs formation and their potential toxicity.

Another rapidly developing research direction involves biocomposites reinforced with natural fibers (such as flax, wood pulp, or cellulose), which are increasingly replacing conventional plastics due to their biodegradability, improved mechanical performance, and reduced dependence on fossil-based resources. Nonetheless, poor interfacial adhesion between the fibers and the polymer matrix remains a major challenge. This weak bonding can accelerate degradation and, consequently, affect the generation and characteristics of BioMPs.

Recent studies estimate that humans inhale or ingest approximately 300 microplastic particles per day. These particles can further degrade and release reactive byproducts capable of inducing oxidative stress. Therefore, investigating tissue-level responses to BioMPs is essential for accurate risk assessment. Although standardized protocols for evaluating microplastic cytotoxicity are still lacking, hydrogel-based models have emerged as a promising tool for simulating tissue-like environments. Such *in vitro* systems enable more physiologically relevant assessment of BioMPs toxicity.

This project aims to investigate the formation of BioMPs from biodegradable materials with commercial additives and biocomposites, and to assess their cytotoxicity using advanced *in vitro* tissue models.

Human occupational exposure to microplastics

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Microplastics (MPs), synthetic polymer particles ≤ 5 mm, have become pervasive in all environmental compartments. Despite growing awareness of their environmental and human health impacts, occupational exposure to MPs remains largely underexplored. A literature review on occupational exposure revealed that MP concentrations in workplaces vary widely, ranging from 4 fibers/m³ in offices to nearly 4,000 MPs/m³ in waste segregation and recycling facilities. The levels detected depend primarily on work activity and proximity to plastic processing operations. Work environments with intensive plastic handling—such as manufacturing, extrusion, and post-processing workshops—consistently showed the highest MP abundance and diversity. The most frequently detected polymers included polypropylene, polyethylene, polyethylene terephthalate, polystyrene, rayon, acrylonitrile butadiene styrene, and ethylene propylene diene monomer. Most airborne MPs are smaller than 100 μ m, enabling prolonged suspension in the air and longer respiratory exposures. In some industrial settings, MPs below 10 μ m – capable of bypassing mucociliary clearance – have been reported. Studies using biological indicators confirmed human exposure to MPs through the skin, hair, and facial masks after work shifts, suggesting the existence of multiple exposure routes. Comparisons between workplaces and households found higher MP levels in occupational settings, particularly in places where plastic materials are processed or handled. Overall, existing evidence highlights occupational environments as a relevant and overlooked source of MPs exposure. However, the absence of standardized sampling, identification, and quantification methods hampers the direct comparison across studies. Future research should prioritize harmonized analytical approaches, propose occupational exposure limits, and recommend protective measures, such as improved ventilation and high-efficiency personal protective equipment, to prevent occupational exposure and mitigate related health risks.

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Microplastics impair behavioural defences against predators in amphibian larvae

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Exposure to microplastics—plastic particles ranging from 1 µm to 1 mm in diameter—has become a major global concern. These particles are now known to accumulate in soils, freshwater and marine environments, and even in the atmosphere, resulting in widespread exposure of organisms to their potential effects. While the physiological impacts of microplastics have received growing attention, relatively few studies have focused on their influence on animal behaviour, and even fewer have explored how they may alter adaptive behavioural responses to natural stressors. Here, we reared agile frog (*Rana dalmatina*) tadpoles under three conditions: (i) water exposed to microplastics (180 particles per ml), (ii) water containing natural microparticles (silicon dioxide; SiO₂) in the same size and concentration, and (iii) particle-free control water. We quantified locomotor activity and risk-taking behaviour in the presence and absence of a dragonfly larva predator. As expected, both control and SiO₂-exposed tadpoles showed a strong decrease in activity and risk-taking under predation risk. However, this strong reduction in risk-taking behaviour disappeared under microplastic exposure. These findings suggest that microplastic pollution can selectively disrupt adaptive components of behavioural plasticity, in this case eliminating risk-taking behaviour while leaving general activity suppression intact. Although the prevalence of such indirect effects in the wild remains unknown, our results emphasise that the absence of direct physiological impacts does not necessarily equate to unaffected fitness.

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Acute, size-dependent effects of oral microplastic exposure on liver and lipid biochemical markers in rats

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Although chronic exposure to microplastic particles (MPs) has been widely investigated, data regarding early biochemical responses following a single exposure are limited. This study aimed to assess the acute, size-dependent effects of orally administered MPs on liver function and lipid metabolism in male Wistar rats.

Polyethylene terephthalate (PET) MPs were obtained by filing plastic bottles and characterized. Animals were randomly divided into four groups: a control group receiving 2.5 mL of Milli-Q water (Q), and three treatment groups receiving MPs at 35 mg/kg with mean particle sizes of approximately 41 µm (S), 70 µm (M), or 106 µm (L), dispersed in 2.5 mL of Milli-Q water. A single dose was administered via oral gavage. After 24 hours, animals were euthanized and blood samples collected. Serum was analysed for liver function markers (aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), γ -glutamyl transferase (GGT), total bilirubin) and lipid profile parameters (total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL), and low-density lipoprotein cholesterol (LDL)).

A size-dependent alteration in biochemical markers was observed. AST levels increased in all MPs-treated groups, most prominently in the S vs. Q group ($p < 0.01$), with a moderate increase in M and L groups vs. Q group ($p < 0.05$). TG levels increased significantly in S ($p < 0.01$) and M ($p < 0.05$) groups vs. Q group, indicating an early disturbance in lipid metabolism. No notable changes were detected in other investigated markers.

A single oral exposure to PET MPs may induce rapid, size-related biochemical responses within 24 hours, with smaller particles showing a stronger tendency to affect hepatic and metabolic parameters. These findings suggest that particle size could be an important factor in early MP-induced effects and highlight the need for further studies to clarify the underlying mechanisms of action.

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Investigation of interactions of water-soluble acrylic acid-based polymers with activated sludge

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Synthetic polymers in liquid formulation are produced in large quantities and applied in various industries. Synthetic water-soluble polymers are used in agriculture, household cleaners, printing inks, lubricants, paints, adhesives, personal care products, and cosmetics. They often end up in wastewater, which is then treated in wastewater treatment plants before being released into the environment.

The aim of the study was to investigate the effects of synthetic water-soluble polymers on activated sludge. For this purpose, we selected homo- and copolymer of polyacrylic acid (PAA) as model synthetic water-soluble polymers. We investigated the adsorption on activated sludge, the changes in sedimentation properties of activated sludge, the effects on endogenous and exogenous respiration of activated sludge.

The results showed that the homopolymer and copolymer were rapidly adsorbed on the activated sludge immediately after the initial contact. Thereafter, the total adsorption was stable with small fluctuations, and after six hours, the maximum adsorption of homopolymer and copolymer was 82% and 73%, respectively. The adsorption process was described by the Freundlich isotherm model. The adsorption of copolymer affected the sedimentation rate of activated sludge. The endogenous and exogenous respiration of the activated sludge was not significantly affected by the presence of homopolymer or copolymer. However, both PAA were not biodegradable and thus there is a potential for their persistence in wastewater treatment plants or in soil, when activated sludge is used as a fertilizer.

Microplastics in the food chain – pathways of entry and awareness

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Microplastics, defined as particles smaller than 5 mm, are increasingly recognised as emerging environmental contaminants. They can move through ecosystems and reach humans via air, food, water, or dermal contact. Although the World Health Organization has highlighted these exposure pathways, standardised methods for their detection and characterisation are still lacking. Consequently, research teams use diverse analytical strategies to identify and quantify microplastics in marine, terrestrial, and food environments.

Our research focuses on microplastics within the terrestrial food chain, particularly in poultry production. We analysed poultry faeces from different farms to identify potential contamination sources and examined rearing environment for the presence of microplastics. Almost all sample types contained microplastic particles of various sizes, shapes, colours, and polymer compositions.

These findings suggest that microplastics may compromise the chemical and microbiological safety of food. Due to their organic and hydrophobic nature, microplastic surfaces can accumulate food residues and other particles, promoting microbial adhesion and biofilm formation. Such biofilms can act as carriers of pathogenic microorganisms, representing a potential risk for food contamination and posing a challenge for hygiene and safety in food production systems

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***Pseudomonas* spp. biofilms enable *Campylobacter jejuni* survival on microplastics**

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Campylobacter jejuni is a leading cause of bacterial gastroenteritis in humans worldwide. This microaerophilic bacterium cannot tolerate atmospheric oxygen concentrations, yet it frequently encounters aerobic environments in food-processing settings. Poultry intestines is a primary reservoir and source of human exposure: carcasses can be contaminated during slaughter and cutting, while chilled storage promotes psychrotrophic communities on meat and packaging surfaces. *Pseudomonas* spp. dominate these niches, potentially creating oxygen-buffered microenvironments that transiently shelter microaerophiles. In our previous investigations, we also detected microplastics on packaged chicken meat, suggesting particle shedding from packaging and raising the possibility that such particles serve as mobile substrates for biofilm-mediated protection and pathogen transfer.

Thus, we investigated the effect of 24-hour *Pseudomonas* spp. biofilm pre-coated on microplastics on *C. jejuni* survival under microaerophilic and aerobic atmospheres at 37 °C. Chicken-meat isolates of *Pseudomonas aeruginosa*, *Pseudomonas lundensis*, and *Pseudomonas fragi* were pre-coated on 5 mm microplastic particles cut from commercial polyethylene terephthalate poultry packaging. Pre-coated or uncoated microplastics were co-incubated with *C. jejuni* under aerobic or microaerobic atmospheres, and viability was quantified by plate counts (CFU). The benefit of *Pseudomonas* pre-coating on *C. jejuni* survival was limited to aerobic conditions. Under aerobic atmosphere, pre-formed biofilms on microplastics increased recovery of *C. jejuni* relative to uncoated particles. Under microaerobic conditions, *C. jejuni* remained viable on both pre-coated and uncoated microplastics with negligible additional benefit from pre-coating; notably, no survival was detected in the presence of a *P. aeruginosa* biofilm. Pre-coated *Pseudomonas* spp. biofilms on microplastics potentially act as oxygen-buffered shelters that allow *C. jejuni* persistence at time scales relevant to processing and storage. These findings indicate that microplastics can act as biofilm-associated vectors, enabling pathogen survival under unfavourable conditions and facilitating its transfer in food-processing environments.

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Ecotoxicological study of an important industrial material adipic acid and its symmetrical esters and their mixtures

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Thousands of chemical compounds are used in the production of conventional and bioplastics as monomers, polymerization aids, and additives to modify their physical and chemical properties. Although their market importance is increasing, detailed information on the composition and quantity of these additives remains limited due to industrial confidentiality. Many of these substances, including newly introduced phthalate alternatives, can leach from plastics under environmental conditions, yet their individual and combined ecotoxicological effects are still poorly understood.

Our work focuses on adipic acid (ADP), a dicarboxylic acid of great industrial importance, and its three symmetrical diesters: dibutyl adipate (DBA), diisobutyl adipate (DIBA) and bis(2-ethylhexyl) adipate (DEHA), as well as all possible 1:1 mixtures of those, using ecotoxicological methods. The additives and their mixtures were tested using standardized 30-minute acute (ISO 11348-3) assay and chronic bioluminescence inhibition tests with prolonged (25h) exposure based on *Aliivibrio fischeri*, as well as a 120-hour contact time ZETA test (Zebrafish Embryo Toxicity Assay) based on zebrafish embryos (*Danio rerio*).

Among the additives, DIBA proved to be the most toxic ($EC_{50}=2.1$ mg/L) in acute bioluminescence inhibition tests, while among the mixtures, ADP+DIBA+DEHA ($EC_{50}=1.9$ mg/L) and DBA+DIBA+DEHA ($EC_{50}=2$ mg/L) demonstrated the highest level of toxicity. In chronic bioluminescence inhibition tests, DIBA (10 hours $EC_{50}=4.8$ mg/L, 15 hours $EC_{50}=5.7$ mg/L), while among the mixtures, DBA+DIBA+DEHA was revealed to be the most toxic (10 hours $EC_{50}=1.5$ mg/L, 15 hours $EC_{50}=1.4$ mg/L), respectively. DIBA was also the most toxic in ZETA tests ($LC_{50}=5.1$ mg/L).

Dialkyl adipates are just one additive group among many; nearly 30,000 plastic additives are used in the European Union, yet our ecotoxicological understanding of a significant fraction of them is incomplete. Our results contribute to expanding our ecotoxicological knowledge of the effects of widely used plastic additives.

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Index-based environmental risk assessment of micro- and nanoplastics: handbook for conscious, accurate, and standardized use

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Pollution from micro- and nanoplastics currently represents one of the main environmental challenges, raising concerns both for its ecological consequences and for the potential risks to human health. After two decades of data collection since the first appearance of the term “microplastic” in the scientific literature, research is moving toward a new direction — that of assessing ecological and human health risks. In this perspective, a rising interest is converging on the use of indices, which may represent an effective tool for describing environmental quality in a clear and straightforward manner.

This contribution, based on the systematic review of 316 papers collected from the Web of Science database, aims to examine the use of indices for environmental risk assessment from both an editorial perspective (when the first publication dates back to, how the topic has evolved over time, and which publishers and journals have shown the greatest interest) and a technical point of view (which and how many indices have been proposed to date, which environmental matrices have been considered, and which geographical areas have received the most attention). Furthermore, what limitations do each index present, and how can they be improved? The goal is to gather and summarize all information on the topic, which to date remains somewhat fragmented, and propose a roadmap to guide researchers and practitioners through an informed, accurate, and standardized use of indices for ecological risk assessment of microplastic pollution.

Exploring the degradation of microplastics after gastrointestinal digestion

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Microplastics (MPs) are pervasive in food, water, and air, making their behaviour in the human gastrointestinal (GI) tract a central question for exposure and risk assessment. This study coupled a standardized *in vitro* GI digestion sequence with Fourier-Transform Infrared Spectroscopy (FTIR) to derive general polymer-agnostic patterns that can guide the interpretation of digestion-conditioned MPs. Four widely used plastics that are also plausible ingestion candidates were analysed: PTFE, PMMA, PA6, and LDPE. Across all polymers examined, the main backbone structure was retained throughout digestion: no markers of bulk scission or formation of new polymer-derived functional groups under the applied conditions were found. In contrast, surface-level changes were consistent. First, the native polymer bands decreased in intensity after digestion, which is compatible with interfacial conditioning (protein/water adsorption) rather than degradation. Second, bands in regions typically associated with protein signatures showed broadening, including amide I/II and a broad N-H/O-H envelope ($\sim 3500\text{-}3000\text{ cm}^{-1}$), which is consistent with a protein-rich interfacial layer and increased surface hydration. Third, a new, transient peak emerged during the oral phase and diminished thereafter (near $\sim 2070\text{ cm}^{-1}$ in our system), reflecting digestion-medium carryover rather than changes to the polymer backbone. Taken together, these findings support a general model in which MPs preserve their core chemical identity through GI-like processing while undergoing subtle but detectable interfacial reconditioning. The recurring FTIR hallmarks are (i) attenuation of native bands; (ii) broadening in protein-linked regions; and (iii) a transient new peak linked to the digestion medium that washes out downstream. Future work is needed to further characterize these surface changes and test their impact on cell interaction and toxicity, using advanced surface analyses and expanded, orthogonal *in vitro* endpoints to identify potential risks for human health.

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Microplastics enhanced mobility on natural beds: the combined roles of abundance and bed roughness

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Transport of microplastic by rivers has been addressed through “sediment analogy”, thus leveraging present well-established knowledge on the transport of natural (clastic) sediments to advance process understanding. The behaviour of negatively buoyant microplastics appears, indeed, advantageous for such an analogy, still limitations highlighted in past studies only address the difference between sedimentary and microplastic particles characteristics (i.e. shape and density). Microplastics and sediments transport occur in river systems, and they share the same physics. Onset of transport conditions for microplastics, however, cannot be fully explained with the classical sediment relations, and this is due to two main limitations: the mobile particles’ availability and the role of bed roughness, both of which have a parallel in sedimentary systems. Their interplay triggers higher mobility, than the one expected by the classical sediment framework, and here we briefly discuss the main reasons, and link them to analogous sedimentary processes.

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Airborne microplastics in the inhaled atmosphere.

Cytotoxicity assesment of air pollution particles.

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Ambient air pollutants pose a significant risks to human health, ecosystems and vegetation; therefore, continous monitoring is essential to understand their concentration levels and associated impacts. Air pollution has long been recognized as a major contributor to increasing morbidity and premature mortality [1,2]. Accorindg to World Health Organization, in 2016 approximately 8 million people die annually from exposure to polluted air [3]. While particulate matter (PM_{2.5} and PM₁₀) is traditionally considered one of the primary indicators of air quality, and is routinely monitored worldwide, emerging evidence suggests that airborne micro(nano)plastic particles (MNPs)– often embedded within or co-transpoartes by PM – may play a far more crtical role in driving adverse biological response. Due to chronic exposure, MNPs can enter the human body through inhalation, ingestion and dermal deposition. Therefore, evaluating their cytotoxicity is essential , as mass concentration alone does not adequately reflect the complexity or biological reactivity of airborne particulate pollution [4].

The objective of this study was to characterize the toxic mechanism of PM_{2.5}/10 and MNPs collected from five different cities in Podkarpackie region, selected to represent urban, industrial, and health-resort environment. We assessed the cytotoxicity and migration-modulating effects of extracts derived from ambient air-sampling filters toward the mammalian cells, as wqell as the inhibitory potential of the extracts on the human microbiome. Furthermore, we analyzed the distribution of particulate mass and characterized the morphology and elemental composition of the extracted material using scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM–EDX).

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Beyond the visible: (bio)chemical methods to reveal nanoplastics in blood

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Micro- and nanoplastics (MNPs) are pervasive pollutants increasingly detected in human tissues, yet studying their impact remains a significant challenge due to the limitations of current analytical techniques. Existing methods often suffer from high limits of detection (LOD) or require destructive sample processing that eliminates the biological context necessary to understand how the immune system, specifically white blood cells (WBCs), interacts with these particles.

To preserve the 3D spatial arrangements of blood components, an acrylamide-based (AA) expansion microscopy-based protocol was optimized. In order to achieve high sensitivity and a low LOD, Nile Red (NR) was utilized as a fluorescent probe, leveraging fluorescence microscopy to visualize particles at the nanometer scale. While NR is highly efficient, its affinity for nonpolar molecules typically causes significant co-staining of biological structures like membrane lipids. To circumvent this, enzymatic digestion was utilized as an optical clearing step to remove the biological matrix while the AA gel scaffold preserved the biological structure of the sample. This enabled selective visualization of MNPs with recovery rates of 103% for small (0.6 μm) and 96% for larger (3 μm) particles.

WBC nuclei were successfully labeled with DAPI, achieving a 95% recovery rate and enabling cell categorization via nuclear morphology. Notably, DAPI and NR functioned effectively in combination, allowing for the simultaneous visualization of WBC nuclei in proximity to MNPs.

Research is ongoing to further characterize structural interactions using immunofluorescence and digestion-compatible trivalent TRITON linkers to achieve full morphological visualization. This work establishes a reliable framework for dual MNP and WBC visualization, advancing high-resolution toxicology research in complex biological systems.

Photo-oxidative aging and leaching behavior of sustainable plastics in artificial seawater

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Microplastics (MPs) are considered one of the most important pollutants for ecosystems worldwide. MPs are plastic debris with dimensions less than 5 mm. In the environment, MPs can release low-molecular-weight degradation products, additives, and adsorbed organic pollutants. The need to reduce plastic consumption and pollution has led to the development of new, more sustainable materials, such as recycled plastics and bioplastics. The term bioplastic is used for a polymer that is biodegradable and/or comes from bio-based materials or fossil sources. In this work, we evaluated changes in the chemical and thermal properties of two bioplastic materials, polylactic acid (PLA) and Mater-Bi[®], and a recycled plastic, recycled polyethylene terephthalate (r-PET), after accelerated photo-oxidative aging, and we evaluated their leaching in artificial seawater. Thermal properties have been studied by thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and evolved gas analysis-mass spectrometry (EGA-MS). The organic fraction leached in water has been analysed by gas chromatography–mass spectrometry (GC-MS) after solvent extraction from aqueous phase and derivatisation. Changing of chemical components after artificial aging has been evaluated by pyrolysis–GC-MS (Py–GC-MS). TGA, DSC, and EGA-MS enabled us to determine changes in thermal properties of PLA and Mater-Bi[®] as glass transition temperature, melting temperature, and thermal degradation temperature. In particular, EGA-MS profiles of Mater-Bi[®] showed a decrease of 10 °C in the temperature of the maximum of the thermal degradation peak of the PLA fraction after four weeks of artificial ageing, compared to unaged Mater-Bi[®]. The temperature of the maximum of the thermal degradation peak of the PBS fraction of Mater-Bi[®] remained constant. GC-MS analysis allowed us to identify the leachates resulting from photo-oxidative aging of bioplastics and recycled plastics in artificial seawater.

Removal of amoxicillin by ozone in the presence of microplastics

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The aim of the research was to find out about the effect of microplastics (MPs) on efficiency of wastewater (WW) ozonation containing antibiotic amoxicillin. Wastewater used for experiments was taken from wastewater treatment plant (WWTP) Vrhnika, Slovenia (15 500 PE). Tested polymers were polyvinylchloride (PVC), polypropylene (PP), polyethylene terephthalate (PET), polyethylene (PE) and rubber. MPs were prepared by grinding tubes, pellets and old tires to achieve particle size of $d \leq 800 \mu\text{m}$. Model wastewater was prepared by addition of antibiotic amoxicillin trihydrate (c_??), which is used world-wide in human medicine for treatment of bacterial infections. First experiments with 5 different MPs were accomplished to test their effect on ozonation of WW with and without amoxicillin (6 hours). To evaluate the effect of MPs on ozonation, parameters such as pH, COD, TOC and IC were measured. Additionally, turbidity and color were monitored as well. After the first set of the experiments, we concluded that PVC and rubber affected the ozonation efficiency the most by lowering the pH value and reducing removal of COD/TOC. At the beginning of the experiment saturated brownish color in the ozonated solutions was observed, which later vanished, but on the other hand, increased turbidity was noted. For our further ozonation experiments, we chose PVC. Finally, ozonation of the WW with PVC and amoxicillin was performed. After 6 h of ozonation of WW containing only amoxicillin, significant pH decrease (< 6.00) was noticed and in the presence of amoxicillin, pH reached even lower values (4.91). Lowest removal efficiency (3.15 %) for COD was measured for ozonated sample with increased pH (12.00) containing PVC and amoxicillin. We also conducted ozonation of treated wastewater (TWW) containing PVC and amoxicillin, which gave similar results as ozonation of WW.

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Production and characterization of microplastics from commonly used infant products and applicability for biofilm assessment

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Infants and toddlers are inevitably exposed to plastics in their environment through everyday activities such as breastfeeding, bottle feeding, crawling, mouthing plastic toys, using dummies/pacifiers, and frequent hand-to-mouth contact. These behaviours create distinct routes and levels of microplastic exposure. Microplastics can serve as surfaces for bacterial biofilms, potentially modulating exposure and impacting health. Bacteria present in human milk, naturally transferred during breastfeeding, provide a biologically relevant model for studying interactions between microorganisms and microplastics. This study aimed to investigate the biofilm-forming ability of bacterial isolates from human milk on various microplastics derived from commonly used infant products. Several products from different brands were analysed by FTIR microscopy to identify their polymer composition, and five representative materials were selected to prepare microplastic particles (100–150 µm). The prepared microplastics were characterized and used as surfaces in biofilm formation assays with the human milk isolates. Results demonstrated that biofilm formation varied depending on the type of plastic material. These findings provide insight into how infant-product microplastics may act as surfaces for bacterial attachment and biofilm formation. Understanding these interactions is important for assessing potential impacts on mammary gland health and the development of the infant gut microbiota.

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Composted microplastics from conventional and biodegradable plastic bags induce a stress response in sunflowers

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Single-use plastic bags represent one of the most persistent sources of plastic pollution. Biodegradable alternatives are increasingly promoted as sustainable solutions, yet their behaviour after composting and their potential effects on plants remain unclear. In this study, we investigated the effects of composted microplastics (MPs) derived from polyethylene (PE), home-compostable polybutylene adipate terephthalate (PBAT_HOME) and industrial-compostable PBAT (PBAT_IND) on sunflowers. Cryo-milled MPs were mixed with compost and incubated at 40 °C for 30 days, then mixed with Lufa 2.2 soil to achieve final MP concentrations of 0.05% and 0.5% w/w. Growth, physiological, and biochemical parameters of sunflower were assessed after eight weeks. The effects of growth were modest, as growth rates decreased only at 0.5% PE and 0.5% PBAT_HOME. Additionally, shoot biomass declined with both doses of PBAT_HOME. There were no significant differences compared to the control group regarding leaf number, root biomass, water content, transpiration, or photosynthetic efficiency. However, biochemical and pigment profiles showed consistent changes indicative of stress. H₂O₂ levels increased in the shoots for all treatments and in the roots for both PBAT polymers at both concentrations. Proline content in the shoots increased for all treatments indicating drought-like stress. Total chlorophyll increased in all treatments except for the 0.05% PBAT_HOME, primarily due to a decline in chlorophyll b. Carotenoid levels increased in all treatments except for 0.05% PBAT_HOME, suggesting activation of photoprotective mechanisms. A two-way clustering analysis showed that all treatments—except 0.05% PBAT_HOME—diverged from the control, consistent with activation of stress responses. In conclusion, composted microplastics from both conventional and biodegradable single-use plastic bags altered sunflower physiology, with PBAT-based materials inducing the strongest oxidative stress responses. These results demonstrate that microplastic residues are not inert and remain biologically active after composting and can influence plant metabolism in a polymer- and dose-dependent manner.

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From marine to freshwater sediments: the role of microplastic size in shaping ecosystem functioning

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Sediments are well known to act as hotspots for microplastic (MP) accumulation, yet the effects of MPs on aquatic ecosystem functioning remain largely unexplored. Understanding how MPs interfere with sedimentary processes is crucial to assess broader ecological implications.

Through a 20-days microcosm experiments, we investigated how three polymer types (Polyethylene, Polyurethane, and Tire dust) in two particle size classes (70–210 μm and 210–500 μm) influence organic matter cycling in oligotrophic coastal sediments. We analysed organic matter quantity, biochemical composition, and extracellular enzymatic-driven degradation as proxies of benthic ecosystem functioning.

We observed both polymer- and size-dependent responses. Smaller MPs stimulated extracellular enzymatic activities, accelerating short-term (i.e. after 10 days of exposure) organic matter degradation and carbon turnover. Polymer-specific effects were observed in organic matter quantity, mainly led by lipid accumulation, specifically in tire wear particle-treated microcosms. These findings suggest that MPs can influence both sedimentary trophic status and hydrolytic potential, potentially altering benthic food webs.

Lakes and rivers are other major recipients of plastic pollution, potentially reaching concentrations up to an order of magnitude higher than the oceans. Owing to their semi-closed morphology, limited hydrodynamics, and diffuse local sources of pollution, the response of lacustrine sediments to microplastic contamination may differ substantially in both magnitude and direction from that observed in oligotrophic marine systems.

Therefore, the AWARE project aims to provide additional insights on lacustrine sediments by extending the experimental approach to freshwater systems. Combining biogeochemical analyses here proposed with molecular tools such as metagenomics, proteomics, and phytopigment quantification, AWARE will assess MPs impacts on sedimentary organic matter and community composition.

By integrating insights from marine and freshwater environments, this research will contribute to a comprehensive understanding of how microplastics reshape carbon cycling and ecosystem functioning across aquatic environments.

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Characterization of culturable bacterial communities on common polymers in wastewater treatment environments

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Plastic pollution has implications beyond its ecological effects; microplastics (MPs) are emerging pollutants in wastewater and in the affected aquatic ecosystems, and function as abiotic surfaces for microbial attachment and biofilm development. MPs serve as carriers for antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARGs). In this study, six types of polymers, polystyrene (PS), polypropylene (PP), polyethylene terephthalate (PET), polylactic acid (PLA), polyvinyl chloride (PVC), and low-density polyethylene (LDPE) were used to evaluate the occurrence of ARBs in wastewater-affected biofilms of microplastics. Each polymer type was exposed *in situ* within wastewater environments to enable natural biofilm formation. Culturable bacteria were isolated using selective Chromatic agar media, including those designed to detect colistin- and carbapenem-resistant strains. Phenotypic screening of antibiotic resistance profiles revealed diverse susceptibility patterns across clinically relevant antimicrobials. MALDI-TOF analysis identified *Stenotrophomonas*, *Aeromonas*, *Morganella*, *Enterobacter*, and *Pseudomonas* as the predominant genera. Microbial diversity varied by polymer type, with PS and LDPE supporting broader communities, while PLA and PET exhibited lower colonization. Distinct material-dependent associations were also observed. Notably, several isolates demonstrated resistance to critically important antibiotics, including colistin and carbapenems, underscoring the potential role of microplastic surfaces as reservoirs for antimicrobial resistance.

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Ecotoxicological responses and intake of marine and freshwater model organisms to micro- and nanoplastics (MNPs) with different surface functionalizations

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Micro- and nanoplastics (MNPs) are pollutants of global concern that can induce ecotoxicological effects across different trophic levels. However, the number of MNPs particles to which organisms are exposed and, consequently, their intake rate, is often unknown, and there is still no standardized methodology to assess small plastic particle intake in ecotoxicological studies. In this study, we evaluated the biological responses of three model organisms, such as *Aliivibrio fischeri* (exposed in both freshwater and seawater media), *Daphnia magna* (freshwater), and *Paracentrotus lividus* (seawater), to green, fluorescent MNP particles in five different sizes (150-10-1-0.1 μm and 15 nm). Each size was tested with three different surface conditions (non-functionalized, COOH- and NH₂-functionalized) and three concentrations (0.002%, 0.0002%, 0.00002%, and 0.000002%). Furthermore, the number of particles in the exposure medium was estimated for subsequent assessment of intake in *D. magna* and *P. lividus*. The smallest nanoparticles (15 nm) at the highest concentration elicited the most pronounced effects, including inhibition of bioluminescence in *A. fischeri*, immobility in *D. magna*, and developmental impairment in *P. lividus*. Dose-dependent responses were observed in *A. fischeri* (freshwater medium, 15 nm) and *D. magna* across all particle sizes, with some attenuated responses also dependent on the NH₂-functionalization of the particles. Intake was quantified using epifluorescence microscopy. These results highlight the size- and concentration-dependent toxicity of MNPs, emphasizing the importance of considering nanoscale interactions in ecotoxicological risk assessment.

Degradation of submerged fishing gear and their MP release potential: comparative data from a mesocosm and *in situ* experiment

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Abandoned, lost or otherwise discarded fishing gear (ALDFG) represent a threat to marine environments, through numerous reasons, including ghost fishing, adsorption/ transfer of chemical pollutants, habitat destruction, safety and economic risks associated with sea-based activities. The production of fishing gear (FG) using synthetic plastic fibres increases the longevity of ALDFG in the environment and may induce long-term ecological impacts associated with plastic pollution. Furthermore, extended exposure of ALDFG to environmental factors in the marine environment may lead to the breakage of FG into smaller fragments, and release of microplastics (MPs). This work aimed to evaluate potential degradation of the physical integrity of FG, and its potential to release MPs, in two settings: a mesocosm experiment, and *in situ* (quasi-real environmental conditions). In both cases, FG of different materials (nylon, polyethylene and biodegradable polymers) were exposed to natural seawater. In the mesocosm experiment, FG was placed in 500L seawater tanks, under natural light and temperature conditions, artificial water agitation, and application of hydrogen peroxide solution to prevent biofilm formation. The *in situ* experiment was conducted in a fishing harbour, allowing the influence of natural environmental conditions and biofouling on the FG. Potential MP release was evaluated through analysis of water samples, collected monthly and processed according to established protocols. Polymer identification of MPs was performed using Fourier Transform Infrared (FTIR) spectroscopy. The physical integrity and possible degradation of FG was evaluated through Scanning Electron Microscope (SEM) analysis, to assess physical surface changes; and using FTIR, to assess molecular structural changes in the plastic polymer. Preliminary results showed physical degradation of all types of FG, with a higher degree of changes to the surface of FG exposed *in situ*. Results will be crucial to fill knowledge gaps regarding the mechanisms behind the hazards of ALDFG, namely degradation processes and MP potential release.

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Microplastics in motion: sediment traps reveal vertical fluxes in a deep holomictic lake

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Microplastics are pervasive pollutants in surface waters of lakes worldwide. However, as plastic particles can sink through the water column, microplastic pollution is not restricted to surface layers. Laboratory simulations and modelling studies indicate that particle properties and environmental conditions are key factors influencing the distribution and fate of microplastics in subsurface waters. Yet, a substantial research gap remains regarding the transport and accumulation pathways of microplastics under real environmental conditions.

Here, we present results from a three-year (2023-2025) research study aimed at understanding microplastic fate and behaviour in Lake Lugano (Switzerland and Italy), a deep subalpine lake with high microplastic concentrations in surface waters. Sediment traps were seasonally deployed for one month at 20 m depth (below mixing layer in stratified conditions) to obtain time series of microplastic vertical fluxes. Additionally, changes in sedimentation rate were further analysed in relation to seasonal environmental conditions (e.g. lake thermal stratification, winds and rainfall) and particles morphology (e.g., shape and size).

Preliminary findings reveal pronounced seasonal variability in microplastic sinking rates. During summer stratification, microplastic sedimentation reached a minimum value of 10 particles m⁻² day⁻¹ (July 2023), whereas during winter mixing the flux significantly increased to a maximum value of 150 particles m⁻² day⁻¹ (February 2024). Particles shape also influences settling behaviour, with fibres sedimentation rates slightly more sensitive to changes in density gradients (stratification: 5.1 particles m⁻² day⁻¹, turnover: 143.5 particles m⁻² day⁻¹), compared to fragments (stratification: 1.4 particles m⁻² day⁻¹, turnover: 31.5 particles m⁻² day⁻¹).

These results highlight for the first time the dynamic nature of microplastic transport in a deep holomictic lake and the central role of thermal stratification and particles properties in regulating vertical fluxes. From an ecological point of view, reduced settling during stratified periods may promote microplastic accumulation in the euphotic zone, increasing the possibility of interactions with planktonic organisms.

Biofilm formation on microplastics shaped by environmental factors and polymer type

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Microplastics are ubiquitous in freshwater systems, yet how their interactions with microorganisms shape their environmental fate remains poorly understood — especially for those made from biodegradable polymers. In this study, we investigated how light availability, nutrient balance, hydrodynamics, and pollution influence biofilm formation on conventional polyethylene (PE) and biodegradable polylactic acid (PLA) microplastics, and how biofilms, in turn, modify their physical and chemical properties.

Biofilm colonization profoundly altered the microplastics themselves. Aged PE became denser, aged PLA lighter, and both approached $\approx 1.1 \text{ g cm}^{-3}$, suggesting that biofilm growth can shift microplastic sedimentation potential. Crystallinity of both polymers decreased, reflecting the amorphous overlay of microbial biofilms.

Environmental conditions dictated these transformations more than polymer type. Light was the dominant driver: darkness suppressed biomass growth, chlorophyll *a*, and extracellular polymeric substances (EPS), revealing the key role of photosynthetic microorganisms. Nutrient stoichiometry further shaped communities — nitrogen enrichment boosted photosynthetic growth, particularly on PLA, whereas phosphorus enrichment reduced chlorophyll *a* and EPS. Addition of wastewater altered the community composition, increasing autotroph abundance but decreasing total biofilm mass. Hydrodynamic conditions influenced biofilm morphology: static conditions promoted elongated microbial structures and enhanced EPS excretion on PLA.

Overall, the results show that microplastics are not inert particles but dynamic substrates whose ecological and physical fate depend on the surrounding environment. Our findings highlight the importance of integrating realistic environmental conditions into laboratory experiments to better predict microplastic behavior in freshwater ecosystems.

Co-exposure of microplastics and trace metals – does it affect bioadhesion of microplastics, growth, and elemental composition of aquatic macrophyte?

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Environmental pollution with microplastics poses a significant threat to living organisms. In aquatic environments, microplastics often co-occur with other pollutants, such as trace metals, due to mutual anthropogenic sources. Microplastics can interact with metals e.g., adsorb them and/or influence their mobility and bioavailability. Thus, the presence of mixture of these pollutants may pose new threats differing from impact of each contaminant alone. Yet, research on the combined effects on aquatic organisms is scarce. This study aimed to evaluate the effect of polystyrene (PS) microplastics and lead (Pb), either alone or in combination, on the growth and content of essential metallic elements of the model aquatic macrophyte *Elodea canadensis* Michx. The applied concentrations simulated aquatic pollution conditions, with Pb at 100 µg/L and MPs at 5000 and 10 000 particles/L. Plants were exposed to pollutants in standard Steinberg medium for 7 days. The growth rate was assessed by measuring the shoot length at the beginning and end of the experiment. Adhered MPs were extracted from plant tissues by sonication and counted using a stereo microscope. Elemental composition (selected elements: Pb, Ca, Cu, Fe, K, Mg, Mn, Mo, Zn) in plant tissues was determined using atomic absorption spectrophotometry. The results showed that PS microplastics adhered abundantly to plant tissues and the number of adhered particles was correlated with their concentration in the medium. The growth of *E. canadensis* shoots was only slightly affected by the pollutants. While PS presence did not influence accumulation of Pb in plant tissues, it did alter the uptake of some essential elements, namely Cu, Fe, K, Mg, and Mo. Plant elemental composition was different when exposed simultaneously to Pb and MPs compared to individual pollutant exposure. The observed changes may result from plant stress reaction or interactions between elements during uptake.

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Impacts of polystyrene and tire wear nanoplastics on early development and feeding of blue mussel (*Mytilus edulis*) larvae

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Nanoplastics (NPs) represent an emerging class of pollutants of high concern due to their potential to disrupt early life stages of marine benthic invertebrates. However, remaining gaps exist on how different NPs types, particularly those identified as high risk, such as tire wear particles, can affect larval development and physiology. In this study, we aim to investigate the early development and feeding responses of blue mussel (*Mytilus edulis*) larvae exposed to model polystyrene nanoplastics (PS NPs) and tire wear nanoplastics (TWP NPs). PS NPs were purchased commercially, and TWP NPs were produced by cryomilling car tire material. Both materials were characterized using Nanoparticle Tracking Analysis (NTA), Dynamic Light Scattering (DLS), and Scanning Electron Microscopy (SEM). Adult mussels were collected from the Danish coast and induced to spawn, and embryos were exposed to varying NPs concentrations (up to 2 mg L⁻¹) for 72 h. Developmental success was evaluated by quantifying the proportion of normal D-larvae. Veliger stage larvae were exposed to *Rhodomonas salina* and NPs to assess changes in feeding rate, and it was measured with a Coulter counter.

Preliminary results indicate physicochemical differences (morphology, Z potential and size distribution) between PS NPs and TWP NPs. Exposure to both NPs types produced a reduction in fertilization success. We hypothesize that the complex chemical composition of TWP NPs enhances their toxicity compared to PS NPs. These findings highlight the importance of incorporating environmentally realistic nanoplastics in ecotoxicological studies, to better assess their potential impact on marine organisms.

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A review and analysis of market based innovative financing instruments to finance plastic waste management

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Unmanaged Micro and Macro plastic waste is increasing around the globe. Municipalities struggle to arrange the required finances to set up plastic waste infrastructure and collection networks for circularity and committed climate goals.

Here it is proposed to conduct a secondary literature review-based analysis of both communities led approaches such as informal waste networks and organized structured innovations in financial mechanisms such as EPR, Polymer Premiums, Plastic Credits, Green Bonds based instruments. It is proposed to design a matrix analysis on a scale of their effectiveness on traceability, incentives for stakeholders, investment returns and ease of implementation to recover and retire plastic waste from the environment. This is with the aim to contribute to reducing a “data and gap analysis” of such solutions to design effective policy and financial tools accessible to cities currently struggling with financing plastic waste management infrastructure.

This research gathers evidence-based policies of state-of-the-art innovations in market based and grant based financial mechanisms and instruments available to help municipalities build sustainable pathways to gather data, adequately price plastic waste, transparently track, manage and reduce micro and macro plastic waste for a circular economy in the form of policy guidelines and recommendations.

It is intended that with this review article that it will lead to pragmatic solution-oriented recommendations on how to best structure projects and initiatives for the successful financing of plastic based pollution abatement measures using innovative market based and grant based financial mechanisms.

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Discovery of *Serratia* and *Pseudomonas* strains with polyethylene-degrading potential

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The biodegradation of plastic polymers using microorganisms is viewed as a promising solution to tackle global plastic pollution. In our research, we screen naturally occurring microorganisms in soil for their activity against plastic polymers, especially polyethylene. We focus our research on polyethylene, because in 2023 fossil-based PE production covered 24.6% of the plastics production market, making it the most widely produced plastic polymer globally. PE belongs to the polyolefins group, and its chemical structure consists of repeating ethylene monomers. For that reason, it lacks favorable chemical groups that are susceptible to degradation.

Soil samples were collected from areas representing different land-uses (e.g. areas near traffic routes, areas used for growing crops and areas with limited anthropogenic pressure). Screening was done on PE-containing agar plates. Through screening bacteria belonging to *Serratia* and *Pseudomonas* genus were obtained. Obtained strains were subjected to further testing to assess their ability and performance in biodegrading polyethylene.

Microplastics in construction and build environment

From environmental pollution to circular opportunities

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Plastics play a crucial role in the construction and building industry, the second largest consumer of plastics in Europe. They are used in a wide range of applications, from insulation and sealants to composites and packaging materials. Plastics can also be incorporated into other materials to form indispensable composites and are extensively used as packaging materials within the construction process. However, despite their long service life, building materials inevitably degrade over time, leading to the release of microplastics into the environment.

Microplastics are now recognised as a global pollutant of major concern, yet research addressing their occurrence and behaviour in construction materials remains scarce. Less than one percent of published studies on microplastics have focused on this sector, highlighting a critical knowledge gap.

Our work provides an overview of the current understanding of how plastics in construction contribute to microplastic generation throughout their life cycle, from production to end-of-life stages. We also discuss the potential for integrating microplastics into circular economy strategies, where they may be repurposed as secondary raw materials in new construction products. By summarising recent advances and innovative approaches, we emphasise both the opportunities and the environmental risks associated with these practices, underlining the need for comprehensive evaluation and responsible material management in the construction industry.

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Poly(hydroxyalkanoates) (PHA) as versatile platform against persistent micro- and nanoplastics

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Classic plastics materials play their strength of being persistent in long-lived products such as natural gas and sewage pipelines, and due to low costs, they are abundantly used for many other short-lived items like packaging materials, too. While they can technologically be mechanically recycled to a large degree, experience from the last decades shows that this is challenging to achieve with post-consumer waste. More and more evidence emerges that plastics release persistent micro- and nanoplastics (MP, NP) particles throughout their lifecycles, i.e. in the use phase and during recycling. MP and NP are detrimental to the environment and humans, by carrying non-food grade additives, for instance, into to body alongside absorbed and adsorbed environmental toxins. Biobased feedstocks and recycling can contribute to sustainable development by lowering a product's carbon footprint, but they do not avoid MP and NP emission. Common materials as substitutes for and alternatives to plastics materials are paper, glass and metal, but these cannot directly replace polymer-based materials directly. An interesting solution is offered by poly(hydroxyalkanoates), PHA. These are naturally occurring polyesters, formed by a range of microorganisms as energy storage compounds under certain conditions. PHA have thermoplastic properties. They are very versatile (short-, medium- and long chain length PHA can be deployed as copolymers, blends and composites), offering drop-in solutions for many well-known commodity and engineering plastics materials. Manufacturing is feasible from sugars – preferably from the hydrolysis of lignocellulosic materials – and several side streams such as lipids, as well as from CH₄ by gas fermentation. PHA are fully biodegradable, also in difficult environments such as cold seawater, under aerobic and anaerobic conditions. The rate of biodegradability depends on the grade and the ambient conditions, comparable to silk, starch and wood. Currently, there are approx. 20 manufacturers for PHA globally, with a combined capacity of approx. 100kt/a. This volume can be considered “embryonic” compared to conventional plastics, yet due to their unique set of properties, PHA have been called the next “sleeping giant” in the polymer industry. Current challenges lie in upstream and downstream process development as well as in application development. More information sharing about the possibilities offered by PHA is needed, to obtain successful application examples such as paper coating for disposable coffee-to-go cups, injection moulded coffee capsules suitable for composting and safe and sustainable by design childrens' toys. PHA offer several end-of-life options, where littering is not the preferred option but not a detrimental one any more, and above all, the materials do not shed persistent MP and NP. This presentation gives an update on the state-of-the-art in PHA commercialization.

PET-derived carbon as a potential selective factor for *Bacillus cereus* in landfill bottle-interior microhabitats

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Plastic, including microplastic (MP), pollution is an emerging ecological concern because of its persistence, ubiquity and interactions with microbial communities. While many studies have examined plastic toxicology and abiotic degradation, it remains unclear whether common heterotrophic bacteria can adapt to use plastic-derived carbon when it represents a major fraction of available organic matter, for example inside long-buried plastic bottles in landfills.

This study tests the hypothesis that poly(ethylene terephthalate) (PET) acts as a selective agent shaping the ability of *Bacillus cereus* populations to exploit PET-derived carbon. Sixty wild strains were isolated from the inner surfaces of PET and glass (control) bottles buried for six years at two municipal landfill sites near Warsaw, and their assignment to the *B. cereus* sensu lato / sensu stricto group was confirmed by PCR. The strains are being cultured with and without PET MPs, and their potential use of PET as a carbon source is quantified using complementary approaches: metabolic profiling (MTT assays), growth dynamics measured by flow cytometry, PET-MP mass loss, surface colonization observed by scanning electron microscopy (SEM), detection of degradation by-products using Py-GC-MS and PET structural changes analysed by FTIR.

Analyses completed so far do not support the hypothesis: strains from PET bottles show neither higher metabolic activity nor stronger PET-MP loss than strains from glass controls. Ongoing measurements with the more sensitive chemical and structural methods will test whether subtle PET degradation occurs in this system. Overall, the study will help clarify whether PET derived carbon can act as a selective factor for an environmentally widespread bacterium in habitats where PET contributes substantially to total organic carbon, and thus whether any such adaptations could contribute to plastic bioremediation in these niches.

Austrian Micro- and Nanoplastic Research (AMINAR) - a new platform

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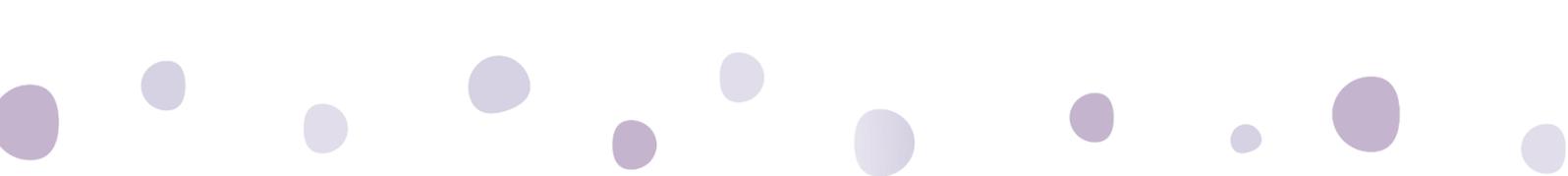
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Micro- and nanoplastics are emerging environmental contaminants of global concern, with increasing evidence of their potential impacts on ecosystems and human health. Addressing these complex challenges requires interdisciplinary collaboration, effective science communication, and support for early-career researchers. The Austrian Micro- and Nanoplastic Research (AMINAR) platform is a newly established non-profit scientific association based in Austria that aims to advance research and knowledge exchange in the field of micro- and nanoplastics. AMINAR seeks to build a sustainable and internationally connected network of experts, fostering collaboration across scientific disciplines and national borders, particularly within Austria and neighbouring countries. The platform promotes the dissemination of scientific information, provides structured discussion forums, and supports innovative research initiatives. Core activities include the organization of scientific discussions, science communication efforts, and a regular webinar series, as well as mentoring and supervision opportunities for young scientists working in micro- and nanoplastic research. Membership is open to researchers both within Austria and abroad. By facilitating collaboration, capacity building, and knowledge exchange, AMINAR aims to contribute to a deeper understanding of micro- and nanoplastics and their implications for environmental and human health. Further information under www.aminar.at.



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