V-NANODAY

5th Edition of the NanoDay International Conference

8th - 9th April 2026, Florence, Italy

BOOK OF ABSTRACTS

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ABSTRACTS

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Scientific Committee

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Programme

V-NanoDay

Auditorium Morgagni

Viale Giovanni Battista Morgagni 40, Florence, Italy -

8-9 April 2026

8 April 2026

8:30 REGISTRATION AND WELCOME

9:00 OPENING ADDRESS

University of Florence, *Vice-Rector for Teaching, Orientation and Student Services, Prof. Ersilia Menesini*

Department of Chemistry "Ugo Schiff", Director, Prof. Stefano Menichetti

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Associazione Italiana Biologia e Genetica Generale e Molecolare, *Treasurer, Prof. Chiara Donati, University of Florence*

9:50 An homage to Florence: Plenary lecture

Prof. Piero Baglioni, CGSI, Dept. of Chemistry, University of Florence, Italy. "Colloids and Surface Chemistry for Art Conservation"

10:20 Session: "Biochar as an innovative nanomaterial"

*Chairs: **Prof. Marta Marmiroli**, Dept. Chemistry, Life Sciences, Environmental Sustainability, University of Parma, Italy*

***Prof. Alessandra Cincinelli**, Dept. Chemistry "Ugo Schiff". University of Florence, Italy.*

10:20 Plenary lecture

Dr. Luca Pagano, Interuniversity National Consortium for Environmental Sciences (CINSA), Parma, Italy. "Biochar as a nanomaterial: from implication to innovation".

10:50-11:30 Coffee break

All posters are on display

11:30 Short presentations

Time	Speaker	Title
11:30	**L. Mondanelli** – Dept. of Agriculture, Food, Environment and Forestry, University of Florence, Italy	Improving sustainability in forest nurseries: reducing peat and water use through biochar-based growing media in chestnut (*Castanea sativa* Mill.) seedlings
11:45	**V. Scanferla** – National Interuniversity Consortium for Environmental Sciences, Italy	Functional comparison between different types of biochar in agriculture [project DeliSoil]
12:00	**F. Demichelis** – Dept. of Applied Science and Technology, Politecnico di Torino, Italy	The digestate-field nexus: improving agronomic outcomes through biochar-integrated anaerobic digestion
12:15	**L. Nolfi** – Dept. for Sustainability, ENEA, Italy; Department of Agriculture and Forest Sciences, University of Tuscia, Italy	Biosafety evaluation of soil improvers from food processing side streams: standardized DNA extraction and molecular analysis protocols. [project DeliSoil]

12:30 General discussion

12:45-14:00 Lunch

All posters are on display

14:00 Session: "Nanomaterials and biofertilisers in agriculture"

*Chairs: **Prof. Jason C. White**, The Connecticut Agricultural Experiment Station, New Haven, CT, USA.*

***Prof. Jos T. Puthur**, Dept. Botany, University of Calicut, Kerala, India.*

14:00 Plenary lecture

Prof. Jason C. White, The Connecticut Agricultural Experiment Station, New Haven, CT, USA. "Controlling the oxidative stress reactome for climate-resilient crops using nanoscale stimulants".

14:30 Short presentations

Time	Speaker	Title
14:30	**M.A. Muawiya** – Dept. of Agricultural and Forestry Sciences, University of Tuscia, Italy	Green nanotechnology for plant health: cellulose nanocrystals restrict systemic movement and mitigate symptoms of *Xylella fastidiosa* infection
14:45	**D. Savy** – Dept. of Agricultural Sciences, University of Naples Federico II, Italy	Novel humic-based nanomaterials as antioxidants and carriers of genetic material for RNAi-mediated pest control strategies
15:00	**S. Falsini** – Dept. of Biology, University of Florence, Italy	Sustainable nanoformulations from olive pomace for enhanced hydroxytyrosol performance in natural pest management
15:15	**S. Carlo** – Interdepartmental Center for Energy and Environment (CIDEA), University of Parma, Italy	SiO_2 nanoparticles application in salt stress mitigation: the case of *Solanum lycopersicum* L.
15:30	**A. Brunelli** – Dept. of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Italy	Advanced nano-based materials as antibiotic-free crop protection
15:45	**M.M.L.H. Forini** – Department of Physics and Chemistry, São Paulo State University, Brazil (online)	Magnetic supraparticles for sustainable delivery systems: release, disintegration, and leaching evaluation

16:00-16:45 Coffee break

All posters are on display

Time	Speaker	Title
16:45	**N.G. Capra** – Dept. of Biosciences, University of Milan, Italy	Small cyclic peptides as targeted biostimulants to improve plant stress resilience
17:00	**F. Martinelli** – Department of Biology, University of Florence, Italy.	Gaining insight into ncRNA-driven regulation of molecular and physiological responses to transparent and blue PET micro-nanoplastics in plants.

17:15 Speech from the organizers

Prof. Nelson Marmiroli, Interuniversity National Consortium for Environmental Sciences (CINSA), Parma, Italy

Prof. Andrea Caneschi, National Interuniversity Consortium of Material Science and Technology (INSTM), Florence, Italy

Prof. Alessandra Cincinelli, Dept. Chemistry "Ugo Schiff", University of Florence, Florence, Italy

18:00 General discussion

9 April 2026

8:30 REGISTRATION AND WELCOME

9:00 Session: "Nanomaterials and nanotechnologies in environmental health"

*Chairs: **Prof. Arturo A. Keller**, Bren School of Environmental Science & Management, University of California Santa Barbara, CA, USA.*

***Prof. Ansa Palojärvi**, Natural Resources Institute (Luke), Turku, Finland.*

9:00 Plenary lecture

Prof. Arturo A. Keller, Bren School of Environmental Science & Management, University of California Santa Barbara, CA, USA. "Nanomaterials at the Crossroads: Market Trends, Environmental Implications and Applications".

9:30 Short presentations

Time	Speaker	Title
9:30	**I. Barbero** – Politecnico di Torino, Italy	Advanced nanoremediation processes for the effective removal of complex mixtures of persistent pollutants from groundwater
9:45	**E. Brivio Sforza** – Dept. of Earth and Environmental Sciences, University of Milano-Bicocca, Italy	Microalgal-based carbon encapsulated iron nanoparticles as novel adsorbents for PFAS removal: from dye proxies to target compounds
10:00	**P. Cinfrignini** – Dept. of Physics and Astronomy, University of Florence, Italy	Separation of gold from wastewater via microporous polymeric materials
10:15	**B. Cerea** – Dept. of Information Engineering, University of Brescia, Italy	Waste based hydrogels for environmental remediation and agricultural applications

10:30-11:15 Coffee break

All posters are on display

Time	Speaker	Title
11:15	**B. Rosso** – Institute of Polar Sciences, National Research Council, Italy	From inland waters to the coast: characterizing small microplastics (<100 µm) and plastic additives across the Venice Lagoon drainage system
11:30	**L. Spagnuolo** – Dept. Chemistry and Industrial Chemistry, University of Pisa, Italy	Safe-by-design immobilization of enzymes on cellulose nanocrystals through green bioconjugation strategies
11:45	**L. Gabellini** – Dept. of Chemistry "Ugo Schiff", University of Florence and INSTM, Italy	Preparation and characterization of advanced catalytic materials for sustainable green energy conversion

12:00 Mini-plenary lecture

Prof. Ansa Palojärvi, Natural Resources Institute (Luke), Turku, Finland. "The DeliSoil Project"

12.20 Mini-plenary lecture

Prof. Alessio Malcevschi, Dept. Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy. "Biochar: a sustainable win-win approach?"

12:40-14:00 Lunch

14:00 Session: "Nanomaterials and nanotechnologies in health and food"

*Chairs: **Prof. Giovanni Tosi,** University of Modena and Reggio Emilia, Department of Life Sciences, Modena, Italy*

***Prof. Andrea Caneschi**, National Interuniversity Consortium of Material Science and Technology (INSTM), Florence, Italy.*

14:00 Plenary lecture

Prof. Giovanni Tosi, University of Modena and Reggio Emilia, Department of Life Sciences, Modena, Italy. "Italian Nanomedicine Platform and Europe Environment"

14:30 Short presentations

Time	Speaker	Title
14:30	**M. Castellucchio** – Dept. of Medicine and Surgery, University of Parma, Italy	Nanoplastics interfere with osteogenic differentiation of human mesenchymal stromal cells
14:45	**R. Caraffi** – Dept. Life Sciences, University of Modena and Reggio Emilia, Italy	One-step self-assembly of lactoferrin nanoparticles for gene delivery
15:00	**G. Danese** – Italian National Institute of Health, Italy	Asymmetric flow field-flow fractionation (AF4) coupled to multiple on-line detectors for the biomonitoring of polystyrene nanoparticles in human urine and serum
15:15	**G. Piccinini** – Dept. of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy	A nanoceria-based multifunctional strategy to counteract early diabetic cardiomyopathy

15:30-16:15 Coffee break

All posters are on display

Time	Speaker	Title
16:15	**C. Pagiatakis** – Dept. of Biotechnology and Life Sciences, University of Insubria, Italy	Metal nanoparticles change the transcription profile via epigenetic modulation
16:30	**C. Vannucchi** – Dept. of Chemistry 'Ugo Schiff', University of Florence, Italy	Natural active-based NLC hydrogels combining pomegranate oil and *Sedum telephium* polysaccharides for pediatric burn management

16:45 Pitch presentations of 10 selected posters (5 minutes)

17:40 Award ceremony for three best oral presentations and one poster presentation

18:00 Conclusion from the organizer Prof. Nelson Marmiroli

18:30 **Closure**

Poster Session: "Biochar as innovative nanomaterial"

Calamandrei R., Magnetic Resonance Center (CERM), Department of Chemistry "Ugo Schiff", Consorzio Interuniversitario Risonanze Magnetiche di Metalloproteine (CIRMMP), University of Florence, Italy. *Solid-state NMR for the characterization of hybrid protein-nanoparticles systems.*

Carlo S., Interdepartmental Center for Energy and Environment (CIDEA), University of Parma, Italy. *Biochar and microbial consortia in basil cropping plant physiology and soil microbiome.*

Haouas A., Interdepartmental Center for Energy and Environment (CIDEA), University of Parma, Italy. *Environmental safety and valorization potential of chars produced from municipal plastic waste in a pilot-scale pyro-gasification process.*

Mignini A., Department of Life, Health and Environmental Sciences, University of L'Aquila, Italy. *Biochar as nanocarrier of endophytic bacteria for Helianthus annuus.*

Mumtaz A., Department of Chemistry "Ugo Schiff", University of Florence, Italy. *Development of biochar & graphene oxide bio-based composite adsorbents for CUPs removal.*

Sabira O., Division of Biomaterial Sciences, Department of Zoology, Sree Neelakanta Government Sanskrit College, India. *Novel synthesis of carbon dots from the defensive secretion of Luprops tristis: characterization and evaluation of antimicrobial, anticancer, and antioxidant activities.*

Scanferla V., National Interuniversity Consortium for Environmental Sciences (CINSA), Italy. *Biochars derived from three agri-food residues beyond soil improvers. Morphological, physiological and molecular effects on tomato (Solanum lycopersicum L) and wheat (Triticum durum Desf) plants.*

Poster Session: "Nanomaterials and biofertilizers in agriculture"

Bindo A., Department for Sustainability, ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy; Department of Agricultural, Forest and Food Sciences (DISAFA), University of Turin, Italy. *Biochar-based soil improvers and microbial amendments shape functional rhizosphere microbial communities in tomato fields.*

Caccialupi G., Department of Life Sciences, University of Modena and Reggio Emilia, Italy. *Agronomic innovations in the cultivation of grain sorghum for the resilience of cropping systems.*

Diya A.M., Department of Botany, University of Calicut, India; Department of Chemistry, CHRIST, India. *Carbon dots enhance UV tolerance via light conversion, photosensitization and nutritional improvement in rice.*

Iosa I., Interdepartmental Center on Safety, Technologies and Agri-food Innovation (SITEIA.PARMA), University of Parma, Italy. *Improving crop resilience through nanobiotechnological approaches.*

Joel J.M., Dept. of Botany, University of Calicut, India. *Integrative use of AMF and calcium oxide nanoparticles enhances mycorrhizal colonization and orchestrates redox homeostasis and photosynthetic performance under NaCl stress in rice.*

Kanerva L., University of Eastern Finland, Finland. *Biofertilizer inoculation alters greenhouse gas and volatile organic compound emissions in Triticum aestivum seedlings.*

Lorenz C., ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy. *Plant Growth-Promoting Bacteria as a sustainable method to enhance drought tolerance in tomato and hemp.*

Nolfi L., Department for Sustainability, ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy; Department of Agriculture and Forest Sciences, University of Tuscia, Italy. *The hidden life of wheat soils.*

Pilotto L., Department of Agrifood, Environmental and Animal Sciences, University of Udine, Italy. *Circular economy and sustainable agriculture: the Cleopatra project Nanohydroxyapatite from biowastes as smart nanofertilizer.*

Purice L., Politecnico di Torino, Italy. *Laboratory investigation of the subsoil transport of sulphur nanoparticles used in viticulture.*

Rustichelli D., Department of Physical and Chemical Sciences (DSFC), University of L'Aquila, Italy; National Interuniversity Consortium of Materials Science and Technology (INSTM), Italy. *Adsorption and controlled release of functionalized metal salts in zeolites with different porosity for agricultural applications.*

Swetha N., Department of Botany, University of Calicut, India. *Nascent g-C_3N_4 and micronutrient doped g-C_3N_4 priming enhances abiotic stress tolerance potential in Oryza sativa*

Poster Session: "Nanotechnologies in environmental health"

Accornero N., IUSS Pavia, Italy; Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy. *Atmospheric particulate matter, health/environmental risk and the role of green and blue spaces: VeBS as Nature Based Solution.*

Armenia I., Department of Biotechnology and Life Sciences, University of Insubria, Italy. *Chitosan nanocarriers for CRISPR/Cas9 delivery in Hermetia illucens for PETase expression.*

Bardelli R., Centro Ricerche Produzioni Animali (CRPA), Italy. *A case of study: Application of best practices to improve the sustainability of dairy farms in Italy.*

Cerea B., Department of Information Engineering, University of Brescia, Italy; CNR-INO, Italy. *Hybrid waste-based chitosan hydrogels for simultaneous adsorption and photodegradation of organic pollutants in water.*

Ciani M., Department of Agriculture, Food, Environment and Forestry (DAGRI), University of Florence, Italy. *Cyanobacteria as green biofactories: synthesis of silver nanoparticles and their antifungal potential against plant pathogens.*

Cinelli P., Department of Civil Industrial Engineering, University of Pisa, Italy; Institute for Physical and Chemical Processes, National Research Council, Italy. *Polybutylenesuccinate-co-adipate (PBSA), a versatile, highly biodegradable matrix polymer for composites and nanocomposites with silica and nano cellulose.*

Corami F.*,* Institute of Polar Sciences, National Research Council, Italy; Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Italy. *Anthropogenic tracers in Venice Lagoon and in its drainage basin: characterization of small microplastics (< 100 µm) and plastic additives in sediments.*

di Domenico K., Italian National Institute of Health, Italy. *Eco-anxiety and Urban Health: The Impact of Nature Loss in the Italian Context.*

Dos Anjos Guimarães G.A.*,* Laboratório de Oceanografia Biológica and Centro de Estudos Avançados da Biodiversidade, Programa de Pós-Graduação em Ciências Ambientais (PPGCA), Universidade Federal do Pará, Brazil. *Microplastic contamination in the Amazon River Delta: a first integrative approach.*

Dos Anjos Guimarães G. A., Instituto de Ciências Exatas e Tecnologia, Universidade Federal do Amazonas, Brazil; Instituto de Geociências, Universidade Federal do Pará, Brazil. *Severe drought intensifies microplastic accumulation in surface waters and sediments of the Amazon River.*

Dos Anjos Guimarães G. A., Laboratório de Oceanografia Biológica and Centro de Estudos Avançados da Biodiversidade, Universidade Federal do Pará, Brazil. *Spatial heterogeneity and local control of microplastic distribution in Amazonian rivers.*

Firdous K.A., Department of Botany, Sree Neelakanta Government Sanskrit College, India. *Green synthesis of silver nanoparticles using Alternanthera tenella Colla: multifunctional bioactivities, metal sensing, and enhancement of chromium phytoextraction.*

Lacchetti I., Environmental and Health Department, Italian National Institute of Health, Italy. *Assessing nanoplastic neurotoxicity with the zebrafish embryo model.*

Lova P., Department of Chemistry and Industrial Chemistry, University of Genova, Italy. *Boosting photocatalytic performance in thin-film systems.*

Mancini A., Italian National Institute of Health, Italy. *Biodiversity restoration and nanotechnologies.*

Palombella G., Ca' Foscari University of Venice, Italy; Institute of Polar Sciences, National Research Council, Italy. *What are we missing? Plastic additives in a drinking water source revealed by non-targeted screening.*

Peralta I., Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy. *Untargeted UHPLC-HRMS combined with multivariate statistics to reveal the effect of nanoparticle-enriched biochars on metabolomics of basil.*

Resmi M.S., Department of Botany, Sree Neelakanta Government Sanskrit College, India. *Microbial and nanoparticle mediated enhancement of phytoextraction in Alternanthera tenella exposed to multi-metal stress.*

Ritarossi C., Italian National Institute of Health (ISS), Italy. *Towards new approach methodologies for micro- and nanoplastics hazard identification: comparative insights on polystyrene and biodegradable particles.*

Salzano de Luna M., Department of Chemical, Materials, and Production Engineering, University of Naples Federico II, Italy. *Soot-derived carbon aerogels as sustainable porous platforms for adsorption applications.*

Stefanović L., Interdepartmental Centre for Food Safety, Technologies and Innovation for Agri-food (SITEIA.PARMA), University of Parma, Italy. *Biochar as a driver of the life-supporting capacity of agricultural soil: effects on soil mesofauna.*

Tebaldi B.S., Universidade Federal do Rio de Janeiro, Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa em Engenharia, Brazil. *Abundance, characteristics, and export of microplastics in urban channels of Central Amazonia, Brazil.*

Tebaldi B.S., Universidade Federal do Rio de Janeiro, Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa em Engenharia, Brazil. *Spatial distribution and composition of solid waste pollution along the banks of the Amazon River, Brazil.*

Tebaldi B.S., Universidade Federal do Rio de Janeiro, Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa em Engenharia, Brazil. *Microplastic pollution in surface water and sediments of Lake Canaçari, Central Amazonia.*

Poster Session: "Nanomaterials and nanotechnologies in health and food"

Alberti S., Department of Chemistry and Industrial Chemistry, University of Genova, Italy. *Microplastic contamination in samples of nephrological interest revealed by micro-Raman spectroscopy.*

Anderlini A., Department of. Life Sciences, and HIP-TECH PhD Program, University of Modena and Reggio Emilia, Italy. *Formulation strategies for a natural-derived small molecule against iron overload disorders.*

Barone L., Department of Biotechnology and Life Sciences, University of Insubria, Italy. *Aged polystyrene leachates affect human dental pulp stem cells.*

Battistini B., National Institute of Health, Italy. *Metal-based nanoparticles in tattooed individuals: insights from human biomonitoring before and after laser-assisted tattoo removal.*

Berto M., Department of Life Sciences, University of Modena and Reggio Emilia, Italy. *Detection of biomarkers through organic electronic sensors.*

Calisi N., Department of Industrial Engineering, University of Florence, Italy; National Interuniversity Consortium of Materials Science and Technology (INSTM), Italy. *Flexible inorganic perovskite thin-films via PVD for real-time dosimetry: from radiotherapy to lunar exploration.*

Condello M., National Center for Drug Research and Evaluation, National Institute of Health, Italy. *Plant-derived nanovesicles: a new drug delivery system for cancer therapy.*

Cuoghi S., Health Innovative Products and Technologies (HIP-TECH) PhD Program and Department of Life Sciences, University of Modena and Reggio Emilia, Italy. *Electrospun PVA nanofibers embedding LNPs for regenerative medicine: a proof-of-concept study.*

Luche S., Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy. *A quantum model organism for quantum dots study.*

Maffei G., Department of Biological, Geological and Environmental Science, University of Bologna, Italy. *NAM-based approaches to understand the toxicological profile of ultrafine PM.*

Salmoiraghi G., Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy. *Polymethylmethacrylate nanoplastics mitigate cadmium effects on human mesenchymal stromal cells.*

Sedani G., Interdepartmental Center for Energy and Environment (CIDEA), University of Parma, Italy. *Nanoengineered surfaces to reduce adhesion of microbes.*

Sforzi L., Department of Chemistry "Ugo Schiff", University of Florence, Italy. *More than just fish: experimental design for microplastic analysis in lipid-rich food.*

Tagliavini S., Dept. Life Science and Health Innovative Products and Technologies (HIP-TECH) PhD Program, University of Modena and Reggio Emilia, Italy. *PLGA–mannose nanoparticles produced by scalable microfluidics for cancer therapy.*

Yousefniayejahromi Z., Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Italy; *Impedimetric aptasensor for the rapid detection of Escherichia coli In biological samples.*

All the abstracts for oral and poster communications are reported in alphabetical order (presenting author).

Plenary Lectures

SCIENTIFIC SESSIONS

- Environment
- Food & Health
- Agriculture
- Biochar as Nanomaterial

Colloids and Surface Chemistry for Art Conservation

Piero Baglioni[1,*]

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Works of art and artifacts that constitute our cultural heritage are subject to deterioration. Their surfaces interacting with the environment are the most prone to aging and decay; accordingly, soiling is a prime factor in the degradation of surfaces, chemical and mechanical degradation are often associated to soiling and lead to the disfigurement of a piece of art. We pioneered the synthesis and the application of several advanced systems for the consolidation and the cleaning of works of art, as hydroxides nanoparticles, microemulsions and chemical/physical gels with controlled nano-, meso-, micro-porosity and tortuosity. Most of these systems constitute a new platform for Conservation of Cultural Heritage and are characterized by scale lengths below 100 nm in one or more dimensions, making neutrons and x-rays the primary tool for the investigation and the tailoring of these systems to the final application. Scattering techniques played a major role in the development of new palette of nano-materials for the conservation, as microemulsions, physical and chemical gels, magnetic gels and microemulsion confined in gels. In this talk, examples from colloids and self assembled nano-systems for the consolidation, the cleaning from soil/grime or the removal of polymer coatings from pictorial surfaces will be highlighted. Calcium (magnesium, barium, strontium) hydroxide nanoparticles have been used for the consolidation of wall paintings and paper conservation, allowing the conservation of important works from western and mesoamerican art. Micellar solutions and microemulsions constitute very efficient systems for the removal of acrylic, vinyl and alkyd polymers or grime/soil. These systems (as well as neat solvents used in "traditional" conservation) can be confined into chemical and physical gels having proper nano-domains for the upload or the delivery of compounds from/to the work of art. For example, a fine control of the cleaning procedure can be obtained even for challenging cleanings as water sensitive works of art, where the cleaning can be achieved by using water confined into gels, leaving no residues on the works of art. Examples from conserved documents/paintings from Beato Angelico, Florentino Codex, Picasso, Modigliani. Lichtenstein, De Chirico, Pollock, etc. will be discussed along with possible future perspectives.

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Nanomaterials at the Crossroads: Market Trends, Environmental Implications and Applications

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The global nanomaterial market has expanded dramatically — from early-stage production in the 1980s to over 1.6 million metric tons in 2020 — and is projected to nearly double by 2031. Commodity nanomaterials such as silicon dioxide, titanium dioxide, and carbon black continue to dominate production, while specialty materials including graphene, carbon nanotubes, and quantum dots are growing rapidly, driven by energy storage, electronics, and automotive applications. Notably, carbon black and nano calcium carbonate dwarf the broader engineered nanomaterial market and are frequently omitted from environmental assessments.

Material flow analyses indicate that the majority of manufactured nanomaterials are routed through wastewater treatment plants, waste incineration facilities, and landfills before reaching the environment, with surface waters, soils, and air receiving smaller but ecologically significant fractions. Personal care products present particular concern given their direct release pathways into aquatic systems, while agricultural applications raise additional terrestrial exposure risks. Predicting actual environmental concentrations requires coupling material flow analyses with environmental fate models — tools that have advanced considerably but remain constrained by limited field validation data, uncertain production statistics, and the complex physicochemical transformations nanomaterials undergo in real-world matrices.

Against this backdrop, engineered nanomaterials also offer compelling opportunities for water treatment, with carbonaceous materials, metal oxide nanoparticles, and emerging framework structures demonstrating high efficacy against heavy metals, pharmaceuticals, PFAS, and microplastics. Bridging laboratory promise and commercial deployment requires resolving cost, scalability, recoverability, and long-term toxicity — challenges inseparable from the broader goal of responsible nanotechnology governance.

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Biochar: a sustainable win-win approach?

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The global biochar market is constantly expanding, driven by a focus on sustainable agricultural and environmental practices. Biochar production is estimated to reach 0.88 million tons in 2026, up from 0.71 million tons in 2025, with projections for 2031 indicating 2.59 million tons. The global biochar market is also estimated to be worth between $500 million and $3.165 billion in 2025, with a CAGR of 24.11% from 2026 to 2031, with multiple reports highlighting rapid growth driven by agricultural soil amendment needs and high-tech pyrolysis advancements. Major growth is concentrated in Asia-Pacific and North America, with 2025 seeing high demand for carbon credits from corporations. A key driver of the biochar market is the growing emphasis on combining use of biochar with carbon sequestration and emissions reduction strategies. When applied to soil, biochar retains nearly 70-80% of its carbon content, significantly reducing carbon emissions into the atmosphere. In this context, to meet the biochar market demand, will users expand its use with a win-win approach?

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Biochar as a nanomaterial: from implication to innovation

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Nanomaterials become example of strategic solutions for agricultural and environmental purposes, which were deeply studied in their molecular responses and potential applicative endpoints. In this context, new sustainable approaches can be considered, including the synthesis of novel materials from raw matter reutilization, such as biochar, that can be chemically or biologically activated.
The utilization of functionalized biochar with plant growth promoting microorganisms (PGPM) lead to develop novel solutions for heavy metal remediation, to implement sustainable strategies to increase crop production, food safety and food security, to develop novel molecular tools as Alternative Testing Strategies (ATS) functional to assess functionalized biochar exposure/effects, with particular regard to early-stage detection at the level of the plant tissues, and soil and to provide support in decision-making and applicability of functionalized biochar bioremediation strategy implementation.

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The Project DeliSoil

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The EU-funded DeliSoil project is a four-year initiative that aims to transform food industry byproducts into safe, sustainable, and tailored soil improvers. This project addresses two pressing challenges: the poor recycling of industrial food processing byproducts and the degradation of soil health. By harnessing a circular approach, DeliSoil will contribute to improving soil health and productivity, supporting the EU Mission "A Soil Deal for Europe" and the Farm to Fork Strategy, as well as other Circular and Bioeconomy Strategies and Plans.

The project will work from 2023-2027 to:
Valorise nutrients and organic matter in food processing side-streams as tailored soil improvers, developing innovative solutions from vegetable, meat, insect cultivation, olive oil, wine and other food industries.
Establish five regional Living Labs and various Lighthouses for researchers, farmers, industries, and citizens to co-create innovations for healthy soils.
Identify technological, financial, legislative and social barriers and enablers in support of these goals.
Establish an evaluation framework for the design, implementation and monitoring of the performance of actions and strategies for improved soil health.
Raise public awareness of soil health and of the safety and potential of circular solutions.

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Italian Nanomedicine Platform and Europe Environment

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The Italian Nanomedicine Platform (INP), coordinated by the NanoItaly Association, is a national network created to connect academia, research centers, clinical institutions, industry, and regulatory bodies in the field of nanomedicine. Officially launched in 2024 and consolidated in 2025, the Platform was established to fill a strategic gap at the European level and to provide Italy with a structured, representative ecosystem in nanomedicine.

Today, INP represents nearly 140 researchers from almost 100 institutions, forming a critical-mass national network with strong academic leadership and growing translational and industrial engagement. The Platform covers the entire innovation pipeline — from fundamental chemistry and nanomaterials engineering to drug formulation, biological validation, regulatory science, and clinical integration — with the goal of translating research into advanced therapies, diagnostics, and precision medicine solutions.

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Controlling the oxidative stress reactome for climate-resilient crops using nanoscale stimulants

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By 2030, agricultural production is projected to decrease by 25% due greater stress from disease, drought, and temperature increases. This concurrence of abiotic and biotic stresses and the losses in food production will threaten food and economic security. Novel plant protection strategies are needed to mitigate these impacts, and nanotechnology can provide crops with enhanced stress tolerance as an effective, safe and sustainable strategy to increase yields. Under stress, cellular redox homeostasis is disturbed, resulting in the accumulation of reactive oxygen species (ROS) that damage biomolecules and inhibit growth. Many nanoparticles (NPs) are ROS-active, such as Cu, Se and silica, and may be applied to crops to stimulate defense systems, prime stress responses, and increase overall crop resilience. Foliar Se nanoparticles (NPs) were applied (5-20 mg/L) on rice 7 days prior to infection with Sheath Blight (ShB)(*Rhizoctonia solani*). Ionic controls and a conventional pesticide (thifluzamide) were included for comparison. Two studies using nanoscale stimulants (SiO_2 and CuO@SiO2 NPs) to prime rice and maize seeds for drought tolerance will be presented. For all studes, an orthogonal approach was used to uncover the mechanisms of plant response to treatment and disease/drought, including electron paramagnetic resonance, Fourier transform infrared spectroscopy, metabolomics, and transcriptomics. Additional measured endpoints included ROS, phytohormone, and nutrient content; antioxidative enzyme activity; root system architecture and yield (quantity, quality). For ShB, foliar Se NPs suppressed disease in rice in a nanoscale specific and concentration dependent manner, decreasing disease severity by 68.8%; this level of control was 1.57- and 2.20-fold greater than Se ions and thifluzamide. For rice and maize, drought stress significantly reduced biomass and yield, but seed priming prevented much of this damage. Collectively, strategies using ROS-active nutrient NPs enhanced disease and drought resilience by activating genes associated with plant defense/immunity, drought tolerance, oxidative stress, phytohormone production, and nutrient uptake/assimilation. By simultaneously boosting crop yield while reducing reliance on pesticides, water and fertilizers, these innovative nano-enabled plant protection strategies enhance climate-resilient crop production and promote sustainable agriculture through efficient resource use.

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Short Oral Communications

SCIENTIFIC SESSIONS

- Environment
- Food & Health
- Agriculture
- **Biochar as Nanomaterial**

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The digestate-field nexus: improving agronomic outcomes through biochar-integrated anaerobic digestion

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This study assesses a closed-loop circular model for food waste (FW) and cow manure (CM) management that integrates anaerobic co-digestion (AcD) with biochar addition, and agricultural exploitation of the resulting digestate. Biochar, produced via digestate pyrolysis, was subsequently reintroduced into the AcD system to mitigate potential process inhibitions and improve digestate quality.

AcD experiments were conducted using an FW: CM ratio of 80:20 (w/w) (to achieve a carbon-nitrogen ratio and pH suitable for AcD) at 6% total solids and a substrate-to-inoculum ratio of 1:1 in 500 mL reactors, operated under mesophilic and thermophilic conditions. Three configurations were tested in quadruplicates: AcD with biochar at 7 and 14 g/L, and without biochar as a control. Digestates from each treatment were tested in a greenhouse pot experiment using tomato plants (*Solanum Lycopersicon* L.), grown in a peat–perlite substrate. Digestates were applied at nitrogen rates of 85, 170, and 340 kg N/ha, with mineral fertilizer, commercial compost, and unfertilized plants as references.

Thermophilic AcD with biochar at 7 g/L achieved 890 NL biogas/kg_{VS}, representing a 25% increase compared to the control and a 44% increase relative to mesophilic digestion. Biochar-amended digestates significantly enhanced agronomic performance by increasing plant biomass by 20% and chlorophyll content by 10% compared to mineral fertilization. Thermophilic digestates favoured vegetative growth, whereas mesophilic digestates promoted superior root development.

This system demonstrates a technically feasible strategy for organic waste conversion into renewable energy, carbon sequestration, and partial replacement of synthetic fertilizers in agricultural systems.

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Improving sustainability in forest nurseries: reducing peat and water use through biochar-based growing media in chestnut (*Castanea sativa* Mill.) seedlings

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This study assesses a closed-loop circular model for food waste (FW) and cow manure (CM) The increasing demand for forest tree seedlings, driven by reforestation and ecosystem restoration initiatives, contrasts with the sustainability challenges faced by forest nurseries. High reliance on peat-based substrates and water scarcity raise environmental concerns, as peat extraction leads to carbon losses and the degradation of water-rich habitats. Research on alternative substrates that improve water-use efficiency and drought tolerance in nursery production remains limited. Few studies have investigated how alternative organic amendments affect plant growth and physiological performance under water deficit conditions in forest nurseries, highlighting a significant knowledge gap. Among potential alternatives, biochar—a carbon-rich material produced by thermal degradation of plant biomass under oxygen-limited conditions—has attracted increasing interest. This study evaluated the effects of incorporating biochar into a standard forest growing medium on the morphological and physiological responses of chestnut (*Castanea sativa* Mill.) seedlings subjected to controlled water stress. Biochar derived from olive pruning residues and chestnut wood produced via slow pyrolysis at 550 °C was incorporated into composite substrates at two rates (15% and 30%, v/v). Eighty-five seedlings were distributed among five treatments: control (100% standard substrate), olive biochar (15% and 30%), and chestnut biochar (15% and 30%). Within each treatment, eight seedlings were subjected to a 21-day irrigation suspension, while seven seedlings were maintained under well-watered conditions. Substrate physico-chemical properties and seedling morphological and physiological responses were assessed under water stress. The results are expected to support the development of sustainable, water-efficient nursery substrates, contributing to peat reduction and enhanced resilience of forest planting material under future climatic conditions.

Biosafety Evaluation of Soil Improvers from Food Processing Side Streams: Standardized DNA Extraction and Molecular Analysis Protocols

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The utilization of environmentally sustainable methodologies for food processing side streams from food transformation, capable of inactivating pathogenic microorganisms, represents an effective strategy towards circular economy implementation, particularly for the production of soil improvers supporting sustainable agricultural practices.
This study aims to assess the biological safety of raw feedstocks and final products obtained through standardized valorization processes of high quality, designed to mitigate relevant microbiological hazards. Both culture-based methodologies and molecular techniques were employed to identify pathogenic microorganisms and potential antimicrobial resistance markers in raw materials and end products. Multiple DNA extraction protocols were applied to different soil improvers matrices, including compost, biochar, digestate, biostimulants, and meat and bone meal, to standardize analytical procedures. Compost and digestate samples underwent specific analyses for the enumeration of *Clostridium perfringens*, *Escherichia coli*, Enterobacteriaceae, Enterococci, and extended-spectrum beta-lactamase-producing *E. coli* strains, as well as *Salmonella* spp. detection. The preliminary screening phase of extraction methodologies enabled identification of the most suitable protocol for each sample type, ensuring high-quality DNA for subsequent metagenomic analysis and development of a tailored extraction protocol customized to different feedstock and soil improvers matrices. Microbiological parameters were evaluated following previously established standardized procedures. All analyzed samples demonstrated compliance with established safety criteria. Microbiological monitoring proves essential to limit the escalation of antimicrobial resistance, and integrated analytical approaches enable comprehensive biosafety assessment of residual materials and soil amendments.

This work has received funding from DELISOIL “Delivering safe, sustainable, tailored & societally accepted soil improvers from circular food production for boosting soil health”, funded by the European Union under the Horizon Europe Program (GA No. 101112855)

Functional comparison between different types of biochar in agriculture

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Biochar is an innovative material used for multiple purposes in agritech, representing a potential sequestrant of soil contaminants, acting as a soil improver or, in some cases, possessing the characteristics necessary to be classified as a fertilizer and thus offering potential benefits to crops by increasing production output directly. Different matrices result in different characteristics in the derived biochar, allowing for comparative work to be carried out to highlight the specificities of each product.

This work focuses on the comparison between three different varieties of biochar derived from wood material and organic waste from multiple food industry supply chains (Meat industry and Wine industry) as per the purpose of the POR-FESR project Meatico, and the project DeliSoil. The comparison is based on a process of characterization of the different biochars in order to investigate the chemical and physical properties of each, the elemental composition, the possible presence of contaminants within the limits set by the relevant EU regulation, and any magnifying effects on production output or potential toxicity at a specified ratio of application.

Short Oral Communications

SCIENTIFIC SESSIONS

- Environment
- Food & Health
- **Agriculture**
- Biochar as Nanomaterial

Advanced nano-based materials as antibiotic-Free crop protection

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Pesticides in conventional agriculture to manage plant diseases faces major limitations, including low efficiency and poor selectivity. As a result, these chemicals are often over-applied, leading to off-target exposure that poses risks to human health and the environment. These challenges underscore the urgent need for safer and more sustainable disease control strategies, particularly for highly destructive plant diseases. One prominent example is fire blight, caused by the bacterium *Erwinia amylovora*, which is responsible for billions of dollars in agricultural losses worldwide each year. Fire blight severely affects blossoms, fruit, shoots, twigs, and branches, and can ultimately cause tree death. Current management practices rely heavily on antibiotics, particularly streptomycin. However, this approach is increasingly unsustainable due to the emergence of antibiotic-resistant bacterial strains and growing concerns over unintended antibiotic exposure to consumers. To address these limitations, this work focuses on the development of antibiotic-free advanced materials (AdMa) for fire blight control. Natural nanoclay AdMa loaded with clove, thymol, or oregano essential oils were synthesized and evaluated for their antimicrobial activity against E. amylovora. *In vitro* studies demonstrated that these AdMa significantly inhibited bacterial growth. Furthermore, field trials conducted at Lockwood Farm (Hamden, CT, USA) on Golden Smoothie apple blossoms revealed that some of the developed materials performed comparably to streptomycin, the current standard treatment in the United States. These findings highlight the potential of essential oil–based nanocomposites as effective and sustainable alternatives for fire blight management.

Small cyclic peptides as targeted biostimulants to improve plant stress resilience

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Abiotic stresses such as drought and high temperatures cause major losses in crop productivity, a challenge that is expected to intensify due to climate change. At the same time, the global population is projected to reach nearly 10 billion by 2050, increasing pressure on agricultural systems to enhance yield while reducing environmental impact. In this context, sustainable strategies to improve plant resilience to environmental stresses are urgently needed.

Plant biostimulants represent a promising tool to enhance crop performance and stress tolerance. However, most products currently available consist of complex natural mixtures with poorly defined compositions and modes of action, limiting their reproducibility and rational optimization. Small synthetic peptides offer an attractive alternative, as they can be precisely designed, sustainably produced, and tailored to modulate specific plant signaling pathways involved in stress responses.

Our research group has developed a platform based on Yeast Two-Hybrid screening of a combinatorial library of 8-amino acid cyclic peptides (CYCLIC) to identify peptides that bind target proteins. Using this approach, we have identified and characterized cyclic peptides able to activate plant immune responses and enhance resistance to pathogen infection. Building on these results, the platform is being extended to the discovery of peptides with biostimulatory activity, targeting key regulators of abiotic stress responses, including hormone-mediated pathways such as abscisic acid signaling. This platform provides a rational and versatile strategy for the development of next-generation peptide-based biostimulants to support sustainable agriculture under climate change.

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SiO_2 nanoparticles application in salt stress mitigation: the case of *Solanum lycopersicum* L.

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Salinity is one of the major abiotic effectors of the plant stress. Crops such as *Solanum lycopersicum* L. might be largely affected in term of plant fitness, fruit quality and production. In this context nanotechnology strategies based on nanosilica ($nSiO_2$) can be applied to mitigate the effects of salt stress. The study aims to assess the potential positive effects of $nSiO_2$ application at physiological, and molecular level; evidence were coupled with synchrotron-based observation related Silicon (Si) uptake and translocation within the plant. Tomato plants were grown in soil amended with $nSiO_2$ or sodium metasilicate (Na_2SiO_3), in conditions salt stress (1% NaCl). Physiological and phenotypic parameters were monitored and leaves and roots samples were analyzed using μ-XRF and RNAseq analyses. Results showed that $nSiO_2$ reduced lipid peroxidation in plant roots under salt stress, although proline content was unaffected. X-ray fluorescence elemental maps showed a higher silicon accumulation in stems treated with Na_2SiO_3, suggesting a greater Si translocation in ionic form. The reduced $nSiO_2$ translocation (as compared with metasilicate) results in a differential gene expression regulation, which underlies potential interaction with plant tissues and organs. By analyzing data through a systems biology perspective, it is observed how $nSiO_2$ offers a promising strategy to enhance salt stress tolerance in tomatoes, providing sustainable solutions to address the challenges posed by increasing soil salinity in agricultural practices.

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Sustainable Nanoformulations from Olive Pomace for Enhanced Hydroxytyrosol Performance in Natural Pest Management

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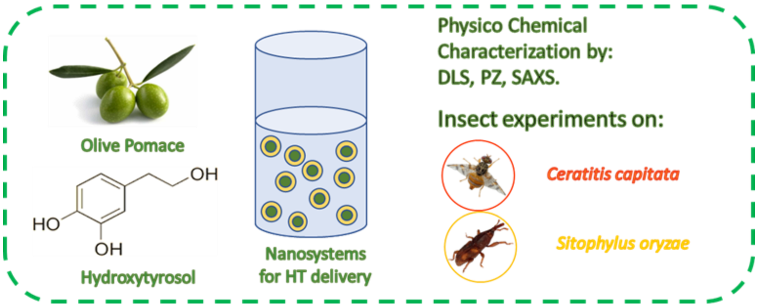
Finely dispersed particles carrying bioactive substances represent an important advancement in crop protection. Among the current options, the most promising are nanoformulations in which the natural molecules are delivered by carriers obtained from agrifood waste materials. In this study, we have devised novel nanocarriers obtained by mixing olive pomace (OP) with egg-yolk phosphatidylcholine (EPC) for the delivery of hydroxytyrosol (HT), a plant-derived phenolic metabolite involved in olive plant defense and suitable for pest management applications. This approach enables the reuse of valuable antioxidants present in agricultural residues, supporting the principles of the circular economy to produce biopesticides. Nanostructures formed from these natural lipid mixtures were loaded with HT dispersed in water at two concentrations 2.5mg/mL and 5 mg/mL. Their stability and reproducibility were confirmed through detailed physico-chemical analyses. Both empty and HT-loaded nanosystems were analysed to obtain information about particle dimensions, surface charge and internal organization at the submicron level. Loaded vectors had an average size of 250−350 nm while their plain counterparts were much larger (d≈1000 nm). The polydispersity index (PDI) of HT-loaded nanovectors was in the range 0.2-0.3, while it was almost doubled in empty aggregates. Regarding the structure, these nanovectors were oligolamellar liposomes, consistently with their composition, since the main components are phospholipids (EPC) and different amphiphilic molecules (OP). The resulting nanoformulations were then administered on two crop pests: *Ceratitis capitata* and *Sitophilus oryzae*. Multifactorial statistical analysis revealed enhanced repellency and reduced oviposition in samples treated with formulations, highlighting their potential for future use in sustainable agriculture.



Schematic representation of the experimental design

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Magnetic supraparticles for sustainable delivery systems: release, disintegration, and leaching evaluation

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Agriculture has faced challenges due to climate change and population growth. In this context, nanotechnology emerges as a promising area in the agricultural sector, using nanoparticles to improve the efficiency of delivering agricultural inputs in the field. The design and manipulation of nanoparticles enable the preparation of larger structural building blocks from clusters of colloidal nanoparticles, called supraparticles (SPs). Supraparticles can retain the properties of individual nanoparticles, enabling controlled release of agrochemicals with low mobility in soil. In this study, inorganic supraparticles were fabricated and characterized from magnetic nanoparticles coated with citrate (Fe_3O_4@Citrate NPs) using the evaporation-induced self-assembly method on a superhydrophobic surface. Scanning Electron Microscopy analyses, coupled with Energy Dispersive Spectroscopy and Stereoscopic Microscopy, highlighted the morphology of the SP and demonstrated the SP's evaporation process over time. An *in vitro* release kinetics study at pH 4 revealed slower release of the micronutrient associated with SPs than with the nanoparticle suspension. Furthermore, the disintegration capacity of the SPs was investigated in different buffers (pHs 4, 7, and 10), and the SPs showed greater disintegration in an acidic medium. Also, studies on the leaching of SPs, NPs, and iron sulfate in soil columns showed reduced mobility of SPs compared to the other formulations, helping minimize environmental impacts from leaching. Therefore, SPs have demonstrated potential as controlled-release systems for micronutrients, with reduced mobility in soil, thereby contributing to agricultural sustainability.

Keywords: supraparticles; nanoparticles; controlled release; sustainable agriculture

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Gaining insight into ncRNA-driven regulation of molecular and physiological responses to transparent and blue PET micro-nanoplastics in plants

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The aim of this study to shed lights into the transcriptional and post-transcriptional regulation of molecular responses to micro-nanoplastic (MNP) stresses in the model plant Arabidopsis thaliana. MNP impacts on the root organ were studied at a molecular level, with a special focus on the role of long non-coding RNAs (lncRNAs) in the regulation of gene expression after PET exposure. Results showed that MNPs of transparent (Tr-PET) and blue (Bl-PET) material reduced plant root length at realistic concentrations, while only Bl-PET significantly reduced rosette area. MNPs provoked oxydative stress markers. Tr-PET upregulated genes involved in signaling of xenobiotics, whereas Bl-PET scarcely affected root transcriptomic profile, activating few gene categories for abiotic stresses. Genes dealing with ABA response were repressed, while brassinosteroid-related genes were differentially regulated by Tr-PET. Both MNPs, but especially Tr-PET, upregulated major latex protein-related genes. Plant molecular response to MNPs was linked to differential abundance of lncRNAs on both comparisons. Tr-PET affected the expression of much more lncRNAs than bl-PET (80 and 11 respectively). A lncRNA (AT1G09297) interacted with CYP81D8, a key gene of cytochrome P450 gene family involved in xenobiotics detoxification. Two lncRNAs interacted with two members of repressed HSP (HSP90 and HSP17.4) family. These data highlighted the need of investigating non-coding RNAs in the future in addition to the mostly studied protein coding transcriptome to understand how nanoplastics affect crop physiology.

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Green Nanotechnology for Plant Health: Cellulose Nanocrystals Restrict Systemic Movement and Mitigate Symptoms of *Xylella fastidiosa* Infection

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The management of *Xylella fastidiosa*, a recalcitrant vascular pathogen threatening global agriculture, remains a critical challenge necessitating sustainable innovation. This study evaluates the therapeutic potential of Cellulose Nanocrystals (CNCs), a renewable nanomaterial, against four genomically distinct strains of *X. fastidiosa* (*CoDiRo*, *TEM1*, *TOS4*, and *IVIA-5387*). *In vitro* assays, ranging from 0.05% to 1.0% (w/v), demonstrated that CNCs exert strong dose-dependent suppression, significantly extending the bacterial lag phase and inhibiting biofilm formation, the pathogen's primary virulence factor. Intriguingly, while culture-based time-kill assays indicated a drastic reduction in culturability, molecular analysis via viability-qPCR (v-qPCR) revealed that cell membrane integrity remained largely intact. This discrepancy points toward a bacteriostatic mechanism, suggesting that CNCs may induce a Viable But Non-Culturable (VBNC) state rather than causing immediate cell lysis. To validate these findings *in vivo*, stem micro-injection of 1% CNCs was assessed in a *Nicotiana tabacum* model system. The treatment proved biocompatible and highly effective, significantly mitigating disease progression and reducing the Area Under the Disease Progress Curve (AUDPC) by up to 85% in susceptible strains. High-throughput spectral phenotyping provided quantitative evidence of physiological rescue; analysis of structural, stress-related, and pigment-specific vegetation indices confirmed that treated plants maintained superior photosynthetic function and avoided the severe stress signatures observed in untreated controls. Furthermore, spatial pathogen quantification indicated that CNC treatment significantly limited the systemic spread of the bacterium within the vascular tissue. These findings position CNCs as a promising, biodegradable tool for vascular pathogen management, shifting the paradigm towards circular and sustainable plant protection strategies.

Keywords: *Xylella fastidiosa*, Cellulose Nanocrystals, Endotherapy, Circular Plant Protection, Sustainable Agriculture.

Novel Humic-based Nanomaterials As Antioxidants And Carriers Of Genetic Material For RNAi-mediated Pest Control Strategies

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Compost-derived Humic Substances (HS), well known plant biostimulants, could be exploited to derive technologically advanced materials.
We hereby optimised the synthesis of HS/chitosan nanoparticles (NP) by progressively increasing the HS amount, and then we ascertained their role in affecting the morphology, the physical-chemical features and the antioxidant properties of the nanocomposites. Spherical NP were obtained, regardless of the content of reactants considered, and a decreasing zeta potential at increasing HS/chitosan *ratio* was observed, whereas higher mean particle size and antioxidant activity were reported at increasingly amount of HS.
We also used one HS-based nanoproduct to deliver double-stranded RNA molecules (dsRNA), to be used in RNAi-mediated insect pest control strategies. Since dsRNA is highly sensitive to environmental degradation, its entrapment was expected to preserve its structure and function. We hereby focused on a dsRNA able to silence an immune gene of the phytophagous *Spodoptera littoralis*. We observed an encapsulation efficiency of over 90%, and a gene silencing efficiency like *non*-entrapped version. Moreover, we noticed an easy NP penetration into tomato leaves, where they stably persisted for 96 hours. We also did not report any alteration of plant physiology, as shown by photosynthetic efficiency measurements.
Our results showed that NP with tuneable reactivity can be obtained from HS. Also, these nanoproducts can successfully entrap and delivery biocides, without displaying toxics effect on plant physiology. Further investigations are encouraged to explore their potential as sustainable radical scavengers and as agrochemical carriers.

Short Oral Communications

SCIENTIFIC SESSIONS

- **Environment**
- Food & Health
- Agriculture
- Biochar as Nanomaterial

Advanced nanoremediation processes for the effective removal of complex mixtures of persistent pollutants from groundwater

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This study aimed to apply ISCR (in-situ chemical reduction) to remediate a real contaminated aquifer affected by multiple chlorinated contaminants, including 1,2-dichloroethane, 1,2-dichloroethylene, vinyl chloride, tetrachloroethylene, and other chlorinated aliphatics, present at concentrations on the order of several thousand µg/L, as well as chlorinated aromatic compounds and metals, particularly arsenic, iron, and manganese.

Laboratory batch degradation tests were conducted on groundwater samples collected from the investigated site. These experiments aimed to evaluate the degradation efficiency towards the target contaminants using both unmodified (passivated) and sulfidated nano zero-valent iron (nZVI and nZVI-S). The degradation kinetics obtained with the two nZVI reactants were also compared.

The results of the laboratory tests highlighted the high efficacy of nZVI in removing the target contaminants. Based on these promising results, an in-field ISCR pilot test was designed and implemented, using *IronGEL nano/mix*, a commercial reagent developed by *DeltaNova*, constituted by a mixture of nZVI and mZVI, with a biopolymers-based formulation which improves stability and injectability in the subsurface.

The pilot test configuration included 3 injection points and 7 monitoring points. Each injection point was planned to receive a total volume of 2000 L, corresponding 80 kg of reactive material.

The results of the monitoring campaign showed an effective distribution of the reagent in the subsoil, along with long-term maintenance of strongly reducing conditions (over 40 weeks). Monitoring data confirmed that the treatment was highly effective, resulting in a significant reduction in the target contaminants, with the sum of chlorinated compounds decreasing by 71-96%.

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Waste Based Hydrogels For Environmental Remediation And Agricultural Applications

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For most industrial processes, waste is an unavoidable by-product that strongly affects environmental sustainability, safety, and socio-economic performance. At the global scale, approximately 1.05 billion tons of food are wasted every year and, together with upstream losses, food loss and waste account for about 8–10% of global greenhouse gas emissions. Similarly, mill scale—an iron-rich by-product of casting, soaking, reheating, and rolling processes—is generated in excess of 13.5 million tons annually worldwide and remains largely underexploited, often ending up in landfills.

In this oral presentation, we present selected examples of recovery and reuse of food and industrial waste to generate new classes of smart, multifunctional materials for environmental remediation, with a particular focus on water purification and their extension as bio-stimulants for horticulture. This strategy relies on the synergistic integration of different functional units derived from waste-based materials, capable of efficiently capturing, detecting, and removing a broad range of environmental pollutants—including pesticides, pharmaceuticals, heavy metals, and polychlorinated biphenyls—or triggering self-protection mechanisms in plants.

Smart hydrogels were developed using chitosan extracted from household shrimp shells and combined, depending on the application, with additives such as titanium dioxide (TiO_2) and iron mill scale from industrial waste [4]. These systems exhibited high efficiency in the adsorption and removal of organic dyes, endocrine disruptors, pharmaceutical compounds, and heavy metals. In addition, chitosan-based nanoparticles demonstrated protective activity against Tobacco Necrosis Virus (TNV).

Overall, these results highlight a waste-aided approach to environmental remediation, emphasizing the relevance of circular and symbiotic chemical strategies for the development of sustainable functional materials.

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Separation of gold from wastewater via microporous polymeric materials

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The increasing presence of contaminants in wastewater - including heavy and precious metal ions, dyes, and micro- and nanoplastics - poses a serious threat to environmental and human health. While traditional methods (e.g., chemical precipitation, ion exchange, filtration) have been widely employed, they are often limited by high operational and environmental costs. In contrast, adsorption-based approaches offer a cost-effective and efficient alternative. Developing innovative and cost-effective materials for the remediation of these pollutants is a critical challenge. Soft hydrogels and cryogels are three-dimensional cross-linked polymer networks capable of absorbing large quantities of water without dissolving and they have gaines attention for their flexibility, biocompatibility, and environmentally friendly nature. Moreover, they show swelling capacity, tunability of the porous structure, and relatively simple procedure of preparation; all these proprieties make them attractive as advanced adsorbent materials.
This study explores the adsorption efficiency and selectivity of a porous acrylamide-based hydrogel (PA) and an acrylic acid-based cryogel (Cryo-H) for the recovery of gold ions from aqueous solutions The performance of both materials is evaluated using a simulated industrial wastewater that closely mimicking effluents from chemical industries processing precious metals; it contains Au, Ru, Ir, Pd, Pt, and Rh, each at concentrations of approximately 10 mg/L. This study highlights the dual function of the hydrogel/cryogel: remediation of contaminated water and recovering valuable and non-renewable metal resources. We characterized and analyzed the swelling behavior and the internal morphology of these polymeric porous matrices to understand the physicochemical interactions underlying metal ion capture, underscoring its potential as an innovative and accessible material for advanced wastewater treatment applications.

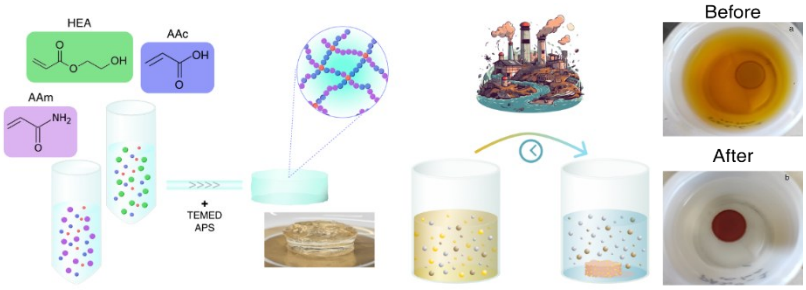

Figure1. Graphical abstract of Acrylamide-based Hydrogel/Acrylic-acid-based Cryogel fabrication and application. (*Left)* Example of mixed metal ions solution appearance before (top) and after (1 week) (bottom) of hydrogel treatment. (*Right*)

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Preparation and characterization of advanced catalytic materials for sustainable green energy conversion

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Hydrogen, due to its importance in our society is probably the most valuable candidate among the energy vectors and exists a route for its photochemical production, making interesting its synthesis from water/methanol solutions via sunlight concentration and harvesting. An active catalyst for this process is titanium dioxide that, when combined with platinum group elements (PGE), is known to reach the production of high quantities of hydrogen per hour. This contribute, developed withing the RESOLCAT PRIN PNRR project, will focus on the synthesis of catalytically active materials made of titanium dioxide nanotubes, decorated with mono- and polymetallic cocatalysts nanoparticles employing the less harmful and more environmentally sustainable preparation route so far, consisting of electrochemical anodizing and dry physical vapor deposition. Methods for the realization of decorated 3D water permeable architectures with an optimized contact between the surface and hydroalcoholic solution, avoiding the use of polluting, expensive and scarce platinum and palladium salts. A combination of electron microscopies (SEM, TEM) and photoelectron spectroscopies (XPS) has been applied, resulting successful in the evaluation of decorated titanium dioxide morphology and on the assessment of deposits' chemical composition, helping us in the complex activity of deposition rate and total amount of metal tuning, reaching the desired stoichiometry with a size control of the cocatalyst, in search of alloyed and monometallic nanoparticles. By that we were able to prove the formation of metallic PGE nanoparticles with interesting catalytic properties.

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From Inland Waters to the Coast: Characterizing Small Microplastics (<100 µm) and Plastic Additives across the Venice Lagoon Drainage System

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Small microplastics (SMPs, <100 µm) represent a growing environmental threat, often underestimated due to the numerous analytical difficulties associated with their reduced size. Similarly, plastic-related pollution, e.g. plastic additives, represents an increasing and challenging environmental issue due to its ubiquity and its chemical complexity. Hence, plastic additives are incorporated during plastic production to enhance their characteristics; however, depending on their chemical bonding within the polymer matrix, they can fragmentated and lead to the leaching with negative consequences for environment. Characterizing the pathways and fate of both SMPs and additives is essential for a comprehensive understanding of anthropogenic discharge into the environment. Since riverine networks and water channels are recognized as primary pathways for the transport of terrestrial plastic debris, a strategic sampling campaign was conducted across the Venice Lagoon drainage basin. Building upon the monitoring activities under the BSL 6 program, this study investigates the assessment of microplastic pollution within a complex hydrological framework, given the complex dynamics of the Venice drainage system. A strict QA/QC protocol was follow to avoid plastic contamination and a previously developed oleoextraction method was employed in a plastic free clean room ISO 7. The quantification and identification of the particles were provided by a Micro-FTIR. The results will provide a comprehensive scientific baseline for the long-term monitoring of the Venice Lagoon drainage basin. This data is essential for supporting regional environmental policies and developing targeted mitigation strategies to preserve the ecological integrity of this sensitive area.

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Microalgal-Based Carbon Encapsulated Iron Nanoparticles as Novel Adsorbents for PFAS Removal: From Dye Proxies to Target Compounds

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This study evaluates the performance of microalgal-based carbon-encapsulated iron nanoparticles (ME-nFe) for the adsorption of PFAS from aqueous solution and the use of synthetic dyes as cost-effective proxies during adsorbent optimization. ME-nFe were produced by hydrothermal carbonization of wastewater-grown microalgae. This new adsorbent combines the fast reactivity of iron nanoparticles with the high adsorbent capacity of the carbon matrix. Furthermore, the encapsulation of the iron makes the materials more stable in water and magnetically recoverable. Laboratory scale batch experiment tested two different dosage of ME-nFe, as well as two pH, at environmental relevant concentrations of 10 PFAS ($\mu g \cdot L^{-1}$). The result showed removal above 90% for medium- and long-chain PFAS and more than 60% for PFOA. Whereas short-chain were weakly removed. Based on their log Kd, Procion Red, 3B Red, Methyl Orange and Sudan Black closely reproduce the adsorption behaviour of medium- and long-chain PFAS on ME-nFe. While PFAS analysis relay on costly HPLC-MS detection and quantification, the dyes can be easily quantified by UV-vis spectroscopy reducing the cost of adsorbent optimization. Overall, ME-nFe emerge as a promising adsorbent for PFAS remediation.

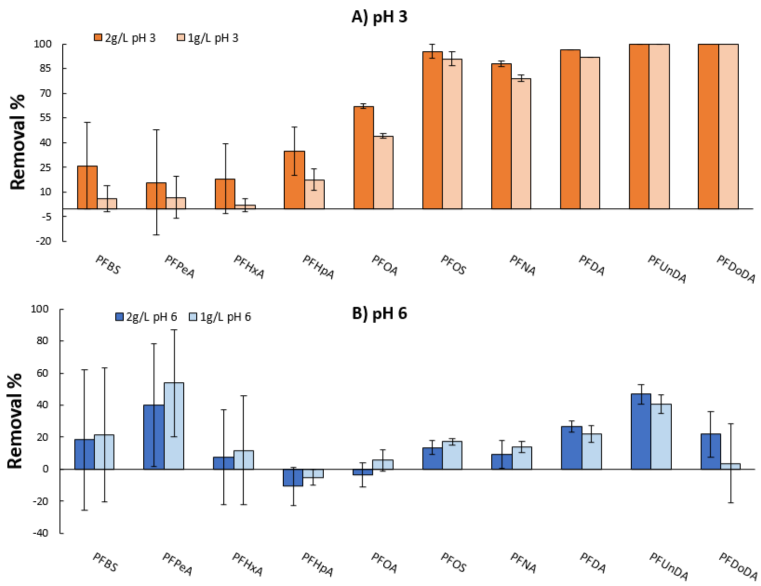

Figure 1. Percent removal of PFBS, PFPeA, PFHxA, PFHpA, PFOA, PFOS, PFNA, PFDA, PFuNDA, PFDoDA. Figure A) shows result at pH 3 for both Me-nFe dosages; Figure B) shows result at pH 6. Data are presented as average and standard deviations (n=4). Cases where removal was negative, the difference between initial (t_0) and final concentrations after treatment was not statistically significant ($p > 0.05$).

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Safe-by-Design Immobilization of Enzymes on Cellulose Nanocrystals through Green Bioconjugation Strategies

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The development of nanomaterials for environmental and industrial applications increasingly requires a safety-by-design approach that integrates performance, sustainability, and intrinsic safety from the earliest stages of material design. In this context, bio-based nanomaterials and environmentally friendly surface chemistries play a key role in minimizing environmental impact and the unintended release of active components. This contribution investigates a sustainable strategy for enzyme immobilization based on cellulose nanocrystals (CNCs) obtained from renewable resources, focusing on how surface chemistry governs the efficiency, stability, and safety of immobilization. *Candida Rugosa* Lipase was immobilized on CNCs through two distinct approaches: non-specific adsorption on sulfated CNCs and covalent bioconjugation on TEMPO-oxidized CNCs using EDC/NHS chemistry in an aqueous medium. The latter approach avoids the use of toxic cross-linking agents such as glutaraldehyde, in line with the principles of intrinsic safety and green chemistry. A comprehensive physicochemical and spectroscopic characterization demonstrates that covalent immobilization leads to near-quantitative binding of the enzyme, significantly reducing enzyme dispersion in water, which is critical for the safe use of biohybrid nanomaterials. Although covalent bonding induces partial stiffening of the enzyme and reduces specific activity, it provides greater stability, structural integrity, and control over protein-nanomaterial interactions. The use of biodegradable, low-toxicity cellulose nanocrystals as supports, combined with aqueous processing and controlled bioconjugation, highlights a design strategy in which safety and sustainability are integrated into the material itself. This work underscores the importance of surface-engineered nanocellulose as a safe platform for future environmentally friendly biohybrid systems.

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Short Oral Communications

SCIENTIFIC SESSIONS

- Environment
- **Health & Food**
- Agriculture
- Biochar as Nanomaterial

One-Step Self-Assembly of Lactoferrin Nanoparticles for Gene Delivery

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The growing focus on safety, efficacy, and sustainability in healthcare has accelerated interest in natural biomaterials for clinical applications. Biomolecules often offer biocompatibility and biodegradability, making them optimal materials for drug delivery nanocarriers. However, successful industrial and clinical translation requires not only effective materials but also scalable and sustainable production processes. In response to this need, significant advances have been made to develop innovative fabrication techniques that offer precise control over nanocarrier properties, high reproducibility, and compatibility with automation. These approaches also reduce the use of hazardous solvents, simplify production, and facilitate regulatory compliance. By combining natural biomaterials with advanced formulation techniques, the field is moving toward clinically viable nanomedicine solutions. In this context, this work presents the development of lactoferrin (LF)-based nanoparticles (NPs) via a heat-induced, solvent-free self-assembly method. Thermal protein denaturation triggered conformational transitions, facilitating NP formation (size ~60 nm, polydispersity index ~0.15, Z-potential +30 mV) with high assembly efficiency (up to 74%). Designed and optimized for gene delivery applications, these NPs efficiently complexed and protected a model small interfering RNA (siRNA), achieving >98% siRNA complexation efficiency. RNase protection assays indicated a maximum siRNA protection efficiency slightly over 60%, whereas naked siRNA was completely degraded. Notably, both frozen and lyophilized LF NPs retained their size, colloidal stability, and siRNA complexation capacity during storage, without the need for cryoprotectants or stabilizers. Ongoing *in vitro* studies in glioblastoma and microglial cell lines are evaluating NP uptake, citotoxicity, and gene silencing efficacy to further validate their therapeutic potential.

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Nanoplastics interfere with osteogenic differentiation of human mesenchymal stromal cells

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Plastic waste mismanagement is causing its accumulation in the environment, where these materials are broken into micro- and nanoplastics (NPs). Once ingested, NPs reach several body districts, raising concerns for human health. While several types of NPs induce oxidative stress, polystyrene (PS) NPs also hinder osteogenic differentiation of mesenchymal stromal cells (MSCs) in animal models. The amino acid glutamine plays several important metabolic roles, is essential for an optimal response to oxidative stress and promotes osteoblast differentiation of MSC. Given that both NP-induced oxidative stress and alteration of glutamine metabolism are known to impair osteogenesis, here we have investigated if NPs alter glutamine metabolism and osteoblast differentiation of MSCs.

PS-NPs are internalized by human MSCs and co-localized with lysosomes, which resulted markedly enlarged. Although PS-NPs did not affect cell viability, they triggered oxidative stress, as demonstrated by glutathione decrease, *HMOX* induction and increase in the activity of the cystine xCT transporter. PS-NPs lowered the expression of the pro-osteogenic enzyme Asparagine Synthetase, while induced the anti-osteogenic Glutamine Synthetase. Consistently, PS-NPs decreased the expression of osteogenic markers (*ALPL, SPARC, COL1A1, ASNS, GLS, SLC38A2*). The inhibition of osteogenic differentiation has been confirmed also in MSCs exposed to poly methyl methacrylate (PPMA) NPs.

In conclusion, PS-NPs cause oxidative stress, dysregulate glutamine metabolism and inhibit osteoblastic differentiation of human MSCs, implying potential links with osteoporosis pathogenesis. Experiments with PMMA-NPs indicate that this is not a peculiar effect of PS-NPs, suggesting that bone may represent a target of exposure to NPs.

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Asymmetric flow field-flow fractionation (AF4) coupled to multiple on-line detectors for the biomonitoring of polystyrene nanoparticles in human urine and serum

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Asymmetric flow field-flow fractionation (AF4) technique coupled to multiple on-line detectors represents a powerful approach for the separation and characterization of nanoplastics in complex biological matrices. This study developed the AF4-based multi-detection method for the biomonitoring of polystyrene (PS) nanoparticles in human urine and serum. Optimized sample preparation protocols were developed to reduce matrix interferences while preserving nanoparticle integrity and minimizing contamination, aggregation and/or particle loss. The AF4 was coupled with complementary detectors, including multi-angle light scattering (MALS), dynamic light scattering (DLS), and ultraviolet (UV) detection, enabling size-resolved detection and semi-quantification of the PS nanoparticle mixture at 20, 60, 100, 200, and 400 nm. Method performances were assessed in terms of sensitivity, recovery and repeatability on mass and size of the PS mixture in human urine and serum. In addition AF4 was not only effective for size-based separation into monodisperse fractions, but also allowed the fraction collection for further complementary and confirming analyses, including size distribution and concentration by nanoparticle tracking analysis (NTA) and single particle inductively coupled plasma mass spectrometry (SP-ICP-MS). The results demonstrated the suitability and robustness of AF4 coupled to multiple on-line detectors for the human biomonitoring application, providing reliable exposure data to support human health risk assessment and regulatory decision-making in the context of nanoplastic contamination.

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Metal Nanoparticles Change the Transcription Profile via Epigenetic Modulation

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Despite significant advances in nanotechnology, a comprehensive understanding of the cellular mechanisms underlying nanoparticle (NP)-induced toxicity, particularly those governing long-term effects, remains limited. Conventional toxicological assays primarily capture acute cytotoxic responses and often fail to detect subtle but persistent, and therefore insidious, molecular alterations. Increasing evidence suggests that epigenetic regulation may play a central role in mediating sustained nano-bio interactions. In this study, we investigated genome-wide epigenetic and transcriptional changes following exposure of NIH3T3 murine fibroblasts to iron-based magnetic NPs. An integrative approach combining chromatin immunoprecipitation sequencing (ChIP-seq) of multiple histone modifications (H3K27ac, H3K4me1, H3K9me2, and H3K27me3) with RNA sequencing (RNA-seq) was used to assess nanoparticle-induced remodeling of chromatin architecture and gene expression. We found that transcriptional responses were predominantly driven by redistribution of H3K27ac at enhancers rather than promoters, indicating that epigenetic modulation of these regulatory regions represents a primary mechanism of NP-induced gene regulation. These epigenetic changes were associated with altered expression of genes involved in stress response, metabolic pathways, and chromatin organization. Notably, enhancer remodeling was more pronounced than promoter-associated changes, highlighting the epigenetic landscape as a sensitive indicator of nanoparticle effects. Moreover, differences in epigenetic marks between iron oxide and cobalt coated iron oxide NPs underscore the role of surface functionalization in shaping epigenetic outcomes. Overall, our findings identify epigenetic reprogramming as a key mechanism in nanotoxicity and support epigenomic profiling as a powerful strategy for evaluating long-term NP safety beyond conventional toxicity assays.

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A nanoceria-based multifunctional strategy to counteract early diabetic cardiomyopathy

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Diabetic cardiomyopathy (DCM) is a multifactorial disease affecting more than 50% of diabetic subjects, characterized by structural and functional myocardial alterations independent of the coexistence of other cardiac pathologies. The development and progression of DCM are associated with several factors, including hyperglycemia, dyslipidemia, mitochondrial dysfunction, and excessive ROS production. Although the pathophysiology of this disease has been studied extensively, the molecular mechanisms involved in the progression of DCM are still not fully understood and effective therapy is not yet available. In the last years, cerium oxide nanoparticles (nanoceria) have emerged as a promising approach in biomedicine due to their excellent self-regenerative antioxidant properties and lack of significant cytotoxicity. This study aimed to evaluate the effects of in vivo nanoceria treatment in the early stage of DCM in a rat model of type 1 diabetes. Untreated diabetic rats exhibited early-onset systolic and diastolic dysfunction, characterized by prolonged contraction and relaxation times at both the organ and cellular level. Nanoceria treatment restored left ventricular contractile performance and improved the mechanical properties of cardiomyocytes. Proteomic analysis revealed that nanoceria interact with cardiac proteins involved in cellular respiration and contractility. In addition, nanoceria reduced ROS levels and enhanced endogenous antioxidant defenses through activation of the circNCX1/Sirt1/Nrf2 signaling pathway. Furthermore, nanoceria treatment improved plasma HDL functionality, promoting reverse cholesterol transport and suggesting broader systemic cardioprotective effects.
Overall, these findings indicate that nanoceria may represent a promising adjuvant strategy to counteract myocardial damage in the early stage of DCM.

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Natural active-based NLC hydrogels combining pomegranate oil and *Sedum telephium* polysaccharides for pediatric burn management

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Pediatric burns require early intervention to control infection, promote healing, and ensure adequate hydration. Currently, no formulations are specifically designed for children. In this study a natural hydrogel based on pomegranate oil—an active antimicrobial and antioxidant lipid—and polysaccharides extracted from Sedum telephium with wound-healing and co-gelifying properties, was developed. Nanostructured Lipid Carriers (NLCs) were employed to incorporate the lipophilic oil into the hydrophilic polysaccharide matrix. Several solid lipids were examined via visual inspection, DSC, and XRD to evaluate solid-state properties and miscibility with liquid lipid; Dynasan 118 was selected for its ability to maximize oil loading and stability. NLCs were prepared using high-shear homogenization and probe sonication, achieving mean particle size ~150 nm and PDI $\leq$ 0.3. Sedum polysaccharides were extracted via hot decoction (yield 17%) and characterized by ^{1}H NMR, UV-Vis, and DLS. The optimized NLC dispersion was incorporated into xanthan-based hydrogels (2.5–5% polysaccharides), displaying pH 5.2–5.5, suitable viscosity, spreadability, adhesion, and syringeability for painless pediatric application. Stability studies were performed on NLC and hydrogel over three months. The developed hydrogel has proven to be a promising, biocompatible, antibiotic-free system for early pediatric burn management, combining effective oil delivery with favorable rheological and application properties.

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Poster Communications

SCIENTIFIC SESSIONS

- Environment
- Food & Health
- Agriculture
- Biochar as Nanomaterial

Atmospheric Particulate Matter, Health/Environmental Risk and the Role of Green and Blue Spaces: VeBS as Nature Based Solution

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Urban air pollution poses a real and growing threat to the health and well-being of citizens and ecosystems. Ultrafine particles $PM_{0.1}$ ($\leq$ 100 nm) are particularly worrying, as they can penetrate deep into the respiratory system and carry toxic substances, although larger particles (PM_1, $PM_{2.5}$, and PM_{10}) are also significant environmental and health risk factors. The VeBS project (The good use of Green and Blue spaces for the promotion of Health and Well-being) promotes the development of multifunctional green and blue spaces, combining the improvement of environmental quality through the maximization of ecosystem services (ES), including the reduction of pollutants in the atmosphere. Urban green spaces play a crucial role in capturing PM thanks to physical mechanisms of deposition on leaves, influenced by morphological and chemical characteristics depending on the plant species. The most efficient tree and shrub species ensure greater PM retention and reduced human exposure. Blue spaces, although playing a secondary role, contribute to microclimate regulation and particle dispersion. Leveraging scientific evidence, the VeBS project is a significant tool for reducing environmental and health risks, thereby ensuring the maximization of ecosystem services for the benefit of urban communities. This approach is achieved through careful scientific research, dissemination, interdisciplinary training of operators and decision-makers, and targeted communication to citizens and stakeholders, constituting a Nature Based solution strategy for citizens' health.

Microplastic Contamination in Samples of Nephrological Interest Revealed by Micro Raman Spectroscopy

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Microplastics (MPs), defined as plastic particles with dimensions between 1 μm and 5 mm, are now recognized as contaminants in several biological systems, such as various human tissues and fluids, raising concerns about possible health implications. In parallel, the growing occurrence of chronic kidney disease (CKD) highlights the importance of investigating potential environmental contributors affecting renal function. In this work, μ-Raman spectroscopy was employed to investigate the occurrence and composition of MPs down to sub-micrometric sizes in human biological matrices (urine, kidney) and medical fluids (peritoneal fluid). The first part of the study focused on human urine samples collected from healthy volunteers and renal tissue obtained from healthy portions of nephrectomy specimens. Particles were identified in both matrices, with polystyrene and polyethylene being the most frequently detected polymers, in addition to several inorganic pigments commonly associated with plastic materials, such as hematite and phthalocyanine blue. The second part of the investigation addressed fluids used for peritoneal dialysis, a widely adopted therapeutic approach for patients with renal disease where the presence of MPs may represent a relevant exposure pathway. Samples were processed by combining aliquots from each 2L bag, followed by filtration through a 0.2 μm PTFE membrane. Polyethylene and polypropylene fragments were detected in the dialysis fluids, suggesting possible contamination associated with manufacturing or packaging processes. Although the toxicological relevance of these findings remains to be fully clarified, the results underline the need for further systematic studies aimed at assessing MPs exposure in dialysis patients and potential clinical implications.

Formulation Strategies for a Natural-Derived Small Molecule against Iron Overload Disorders

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Iron overload disorders pose complex clinical challenges. Hinokitiol (HK) is a promising therapeutic candidate as it can shuttle iron across cell membranes and release sequestered intracellular iron, especially for conditions like Ferroportin Disease (FD), where phlebotomy and iron chelation are often inadequate or burdensome. However, HK's clinical utility is limited by its physical-chemical properties and biodistribution.
In this study, we report the first evaluation of biodegradable and biocompatible Nanomedicines (NMeds) developed for the parenteral administration of HK. Polymeric and lipidic NMeds were evaluated, namely poly lactic-co-glycolide (PLGA), Cholesterol (Chol) NMeds, and Nanostructured Lipid Carriers (NLC). The optimization led to homogeneous NMeds with size < 300 nm and encapsulation efficiency up to 40%, despite the small molecular weight and volatile nature of HK. Drug retention ability was assessed, allowing for the selection of 3 NMeds to be tested on iron-loaded macrophage model (J774 cell line) and human primary macrophages obtained from healthy blood donors and FD patient-bearing two different mutations. Data revealed that all HK-loaded NMeds are non-toxic and can accumulate in the cells, but most importantly they are more efficient than the free HK in reducing the intracellular iron pool. NLCs in particular showed the most promising behavior in terms of high efficacy and low toxicity. These results demonstrate that delivering HK via NMeds is preferable to administering free HK, representing the first step towards the development of a more efficient treatment of this currently challenging disease.

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Chitosan Nanocarriers for CRISPR/Cas9 Delivery in *Hermetia illucens* for PETase Expression

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Polyethylene terephthalate (PET) is one of the most widely used synthetic polymers and a major contributor to global plastic pollution. Its chemical stability makes it highly resistant to environmental degradation, resulting in the accumulation of persistent macro- and microplastic in organic waste. Enzymes such as PETase have demonstrated the ability to hydrolyse PET under mild conditions, offering a promising biological route for polymer depolymerization.

This study investigates the use of biodegradable chitosan-based nanocarriers for the delivery of CRISPR/Cas9 components aimed at enabling PETase expression in the larvae of Hermetia illucens (Black Soldier Fly), an insect species widely applied in organic waste bioconversion. Chitosan nanocapsules were prepared using either ionic gelation or a water-in-oil emulsification method, and the formulations were optimized to maximize nucleic acid encapsulation efficiency. The resulting nanocarriers were characterized with respect to hydrodynamic size, morphology, colloidal stability, and controlled release kinetics.

Future studies will quantify transfection efficiency in insect cell cultures through fluorescence-based uptake analysis, targeted PCR assays to detect CRISPR-induced edits, and enzymatic PETase activity measurements.

Results from this work aim to establish a nanotechnology-enabled platform for gene delivery in insects and to explore the feasibility of engineering H. illucens as a biological system capable of contributing to PET degradation. This interdisciplinary approach integrates nanomaterials science, molecular biology, and insect physiology, providing a foundation for future developments in environmentally sustainable plastic bioprocessing.

A case of study: Application of best practices to improve the sustainability of dairy farms in Italy

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The European Union (EU) aims to achieve carbon neutrality before 2050 by reducing emissions and introducing climate-friendly practices to enhance carbon sequestration and storage. European agriculture impacts for a 10% to total Green House Gases (GHGs) emissions, but the livestock sector accounts for 70% of this. The reduction of livestock sector's impact by sustainable practices is essential to achieve the EU targets. In this context, ZOOCARBON project can contribute by demonstrating how to reduce the Carbon footprint of milk production for Parmigiano Reggiano DPO cheese through application of digestate obtained from livestock effluents. The project involves seven farms located in the Parmigiano Reggiano area, that combines both dairy production and renewable energy production with biogas plant fed only with manure and slurry produced in the own farm. ZOOCARBON project aims to assess the role of sustainable soil management, such as the presence of permanent grasslands, short-term grasslands, crop rotation with cover crops and the use of digestate, for increasing Soil Organic Matter and thus reducing GHG emissions in the Parmigiano Reggiano area. The experimental activities of ZOOCARBON project will lead to the development of a manual of best practices related to the main stages of farm production, such as cultivation, livestock management, and anaerobic digestion process. The research will establish a validated, replicable and sustainable agronomic model as viable solution for the entire Parmigiano Reggiano Consortium proving that localized renewable nutrient management can substantially reduce the carbon footprint of milk production contributing to achieve climate neutrality.

Aged polystyrene leachates affect Human Dental Pulp Stem Cells

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Polystyrene is one of the most commonly used plastic polymers and a major component of plastic debris widely released into ecosystems. We investigated the effects of pristine and aged polystyrene micro- and nanoplastics on human dental pulp stem cells, a subpopulation of mesenchymal stem cells embedded within the pulp cavity of teeth.

Our results showed that, although particles of both sizes were internalized by the cells, primarily through endocytosis, they did not affect cell viability. However, they induced cytoskeletal disorganization, leading to reduced actomyosin cortex integrity.

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

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

Furthermore, to elucidate the chemical nature of the leached compounds, future studies will employ advanced analytical chemistry techniques. Integrating chemical profiling with biological assays will provide a more comprehensive understanding of the potential risks that micro- and nanoplastics pose to human health.

Metal-Based Nanoparticles in Tattooed Individuals: Insights from Human Biomonitoring Before and After Laser-Assisted Tattoo Removal

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As tattooing becomes increasingly widespread, laser-assisted tattoo removal has also become common practice. However, systemic exposure to tattoo pigments and their laser-induced degradation products remains poorly understood. This study investigated human exposure to metal-based nanoparticles (MNPs) associated with both tattooing and laser removal procedures. A human biomonitoring campaign was conducted involving 35 tattooed individuals sampled before and after laser treatment, alongside 14 non-tattooed control subjects. Size distributions and number concentrations of MNPs in blood and urine were measured using single-particle inductively coupled plasma mass spectrometry (SP-ICP-MS). Aluminum and Au MNPs were detected in urine, whereas Ag, Au, Cr, Pb, and Ti NPs were detected in blood samples. Particle size distributions of Ag, Au, Cr, and Pb were predominantly below 50 nm, whereas Al and Ti were mainly detected as larger particles (>100 nm). Furthermore, concentrations of Cr and Ti nanoparticles increased following laser treatment sessions, suggesting that laser-induced pigment fragmentation may promote MNP release. The detection of MNPs in control subjects indicated additional non-tattoo-related exposure sources contributing to overall body burden.

This work provides the first evidence of MNPs distribution in individuals following tattooing and laser tattoo removal, underscoring the need for comprehensive risk assessment, standardized human biomonitoring strategies, and appropriate regulatory measures to address the health implications of these practices.

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Detection of biomarkers through organic electronic sensors

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Bio-recognition is a fundamental and specific mechanism in biological processes in living systems, and it is widely exploited in technological and health applications. Organic Electronics (OE) is an emerging technology perfectly suited to connect electronic devices and biological environment: the biocompatibility of many materials used, the ability to communicate with living systems through both ionic and electronic currents, and the high sensitivity to small variations of potential differences make OE a perfect platform for the realization of specific biosensors.
The works here presented show recent strategies to realize biosensors for health monitoring in real samples based on organic transistors working in aqueous environment (EGOTs).

- Extracellular vesicles (EVs) are emerging as potential biomarkers for early diagnostics of several cancer types. EVs are heterogeneous populations of membranous vesicles of different diameters and cellular origin which can be detected in several bodily fluids and can provide minimally invasive information about health issues.
- Alzheimer's disease (AD) affects more than 50 million people worldwide and it is known to be the most common disease causing dementia. One of the most promising biomarkers is the level of phosphorylated tau (p-tau), since it is considered specific for AD and reflects both the phosphorylation state of tau and the formation of neurofibrillary tangles in the brain.

The results demonstrate the robustness of EGOTs sensing response even in real biological samples, both for the detection and the quantification of biological biomarkers, such as extracellular vesicles and phosphorylated-tau protein.

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Biochar-based soil improvers and microbial amendments Shape Functional Rhizosphere Microbial Communities in Tomato Fields

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Soil degradation and declining biological functionality threaten the sustainability of European agricultural systems, highlighting the need for innovative and circular solutions to restore soil health. Within the framework of the Horizon Europe DELISOIL project, tailored soil improvers derived from food processing residue streams are being developed and evaluated as sustainable tools to enhance soil fertility and biological activity. A key focus of this work is the assessment of these soil improvers, applied alone or in combination with microbial-based inoculants, across different cropping systems.

This contribution presents ongoing laboratory analyses aimed at evaluating soil microbial responses to selected biochar-based soil improvers and microbial amendments, including bacterial consortia. Soil samples collected at different growth stages of tomato plants were analysed to investigate microbial community structure and functional potential. Methodological optimisation of soil DNA extraction was performed to overcome matrix complexity and inhibitory effects, ensuring suitability for downstream molecular analyses. In parallel, microbial functional diversity was assessed using Community-Level Physiological Profiling (CLPP) through BIOLOG EcoPlates to evaluate metabolic activity patterns across treatments. Early assessments showed a transient treatment effect on microbial metabolic activity, with selected amendments enhancing activity at T0, while multivariate analyses indicated that temporal dynamics, rather than treatment, drove a long-term functional convergence across all treatments.

The analyses presented provide the methodological and experimental basis for an integrated assessment of soil biological responses within DELISOIL. Ongoing work will expand these preliminary evaluations through high-throughput sequencing and the integration of physicochemical and agronomic indicators. The results will contribute to the development of harmonised, science-based approaches for assessing the performance of soil improvers and supporting sustainable soil management practices in European agriculture.

This work has received funding from DELISOIL "Delivering safe, sustainable, tailored & societally accepted soil improvers from circular food production for boosting soil health", funded by the European Union under the Horizon Europe Program (GA No. 101112855)

Agronomic innovations in the cultivation of grain sorghum for the resilience of cropping systems

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Sorghum (*Sorghum bicolor*) is a C4 cereal widely recognized for its tolerance to heat and drought. Although it is a staple food crop in many countries, its agronomic and food potential in Italy, particularly in the Emilia-Romagna region, remains underexplored.

The RISORGO project aims to assess the suitability of white sorghum as a climate-resilient crop for rainfed systems, improving water-use efficiency and supporting sustainable food production. The project spans three years and includes two complementary experimental trials: (i) an agronomic trial testing sustainable management practices under rain feed conditions, and (ii) a multi-location trial across different pedoclimatic environments, from the environments of the Po Valley to those of the mountains in the Apennines of Central Emilia.

In the first year, ten sorghum hybrids were evaluated in the agronomic trial, including a biostimulant treatment under rainfed conditions. In parallel, two selected hybrids were tested in ten locations representing a broad environmental gradient. Despite extreme events during the summer, the agronomic trial highlighted good adaptation to water-limited conditions, with medium-maturity hybrids achieving the best overall agronomic performance. The multi-location trial confirmed strong yield stability and broad adaptability of the selected hybrids across environments.

Grain quality and end-use suitability analyses are currently ongoing to validate the potential of white sorghum as a sustainable food crop for the region.

Solid-state NMR for the characterization of hybrid protein-nanoparticles systems

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Protein-inorganic conjugate nanomaterials are increasingly being utilized in fields such as nanotechnology, analytical chemistry, cell biology, and medicine. Their unique hybrid nature is a significant advantage in these applications; however, it also complicates the structural characterization of the various components when they are assembled together. Among these hybrid nanomaterials, proteins conjugated to gold nanoparticles have become well-established tools for immunohistochemistry. Additionally, they show promise as agents for photodynamic therapy, near-infrared optical imaging, and drug delivery. In this study, we demonstrate that a detailed analysis of the intermolecular interactions between a therapeutic target and a clinically approved inhibitor of the immune checkpoint PD-1/PD-L1, which is grafted onto gold nanoparticles, can be effectively achieved using solid-state nuclear magnetic resonance.

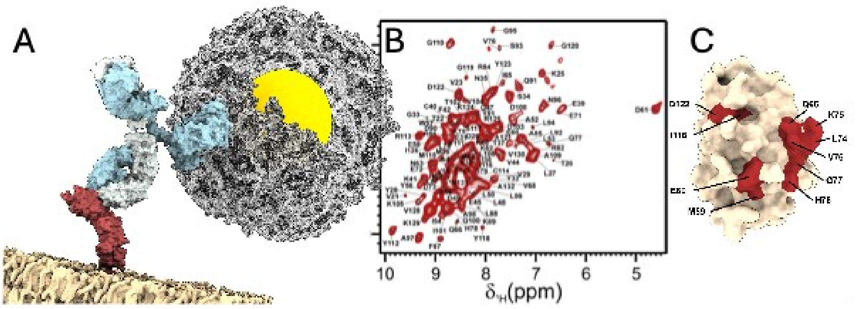

Figure 3. (A) 5 nm gold nanoparticles functionalized with 5 kDa PEG chains bearing NHS-ester (1 NHS group/nm^2) conjugated to the human immunoglobulin G1 (IgG1) monoclonal antibody Avelumab (mAb) that targets the protein PD-L1.(B) 2D ^{15}N ^{1}H (H)NH CP-HSQC spectrum of [U-^{2}H, ^{13}C, ^{15}N] PD-L1 in complex with the anti-PD-L1 monoclonal antibody Avelumab grafted onto AuNPs. The assigned resonances are reported in black. (C) Chemical shift perturbation (CSP) of free PD-L1 in solution with respect to rehydrated freeze-dried PD-L1-anti-PD-L1 monoclonal antibody Avelumab complex grafted onto AuNPs in the solid state.

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Flexible Inorganic Perovskite Thin-Films via PVD for Real-Time Dosimetry: From Radiotherapy to Lunar Exploration

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Halide perovskites are rapidly emerging as excellent candidates for ionizing radiation detection due to their high effective atomic number and superior charge-transport properties. This work presents the development of flexible dosimeters based on nanostructured perovskite thin films realized via Physical Vapor Deposition (PVD).

Unlike traditional solution-based methods, PVD allows for the growth of uniform, compact nanometric thin films on flexible plastic substrates equipped with gold interdigitated electrodes. This specific architecture opens the way for applications in two critical sectors: medical physics and space exploration. In the medical field, the device's conformability enables direct application on a patient's skin, allowing for real-time in vivo dosimetry during radiotherapy to ensure treatment accuracy and safety.

For aerospace applications, these sensors address the challenges of future extraterrestrial missions, a key objective of the ASI and MUR funded "Space It Up!" project. For example, the harsh lunar environment, lacking natural shielding, requires constant radiation monitoring and protection. The lightweight and low-power characteristics of perovskite-based devices make them suitable for integration into astronaut suits and habitat structures.

We present preliminary results on the morphological and electrical characterization of the PVD-deposited nano-films, alongside their response to highly energetic radiation, highlighting the potential of this flexible technology for advanced dosimetry applications.

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Biochar and microbial consortia in basil cropping plant physiology and soil microbiome

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Soil degradation and reduced water retention represent major constraints for crop productivity under climate change conditions. Aromatic crops such as *Ocimum basilicum* L. are particularly sensitive to soil biological and physicochemical imbalance, affecting both yield and physiological performance. In this context, integrated strategies based on soil improvers and Plant Growth Promoting Microorganisms (PGPMs) can be applied to enhance soil health and plant resilience. This study aims to evaluate the combined effects of biochar and clay amendments with selected microbial consortia (MICOSAT F, RhizoVital®, and the Arbuscular Mycorrhizal Fungi (AMF)) on soil microbiome dynamics and basil physiological responses under field conditions. Basil plants were grown in randomized block plots amended with biochar or clay, alone or in combination with microbial consortia. Soil microbiological, enzymatic and physicochemical parameters, together with plant physiological and biochemical traits, were monitored at different time points. Results showed that biochar significantly enhanced microbial abundance and functional groups involved in nitrogen fixation and phosphorus solubilization, particularly at early growth stages, while clay generally reduced microbial activity. Plant responses were strongly dependent on year, sampling time and amendment–microbial combination. Microbial consortia were associated with higher cellular respiration at early stages, while biochar-consortia combinations selectively increased fresh stem and leaves biomass. Oxidative and antioxidant-related traits were differentially modulated by treatments, with biochar–microbial combinations enhancing antioxidant capacity in selected conditions and clay treatments affecting oxidative and stress-related markers. These findings indicate that biochar–microbial consortia integration represents a promising strategy to improve soil biological functioning and crop physiological performance, supporting more sustainable basil cultivation systems.

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Hybrid waste-based chitosan hydrogels for simultaneous adsorption and photodegradation of organic pollutants in water

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The growing scarcity of clean water and the widespread presence of emerging and persistent organic contaminants, such as pharmaceuticals and dyes, pose significant challenges to conventional wastewater treatment technologies. These compounds are often resistant to traditional processes, highlighting the need for sustainable and efficient remediation strategies capable of operating under realistic environmental conditions.

This work presents a multifunctional remediation system based on chitosan-derived hydrogels embedding TiO_2 nanoparticles within a stable polymeric matrix. Chitosan, a biopolymer obtained from food waste such as shrimp shells, enables the integration of waste valorization with water purification. The resulting hybrid material combines the intrinsic adsorption capacity of chitosan hydrogels with the photocatalytic activity of TiO_2, allowing simultaneous pollutant capture and degradation in a single, reusable platform.

The performance of the system was evaluated using aqueous solutions containing dyes and the antibiotic sulfamethoxazole, under realistic ionic strength conditions and both simulated and natural solar irradiation. Structural characterization confirmed the effective immobilization of TiO_2 within the hydrogel matrix, ensuring material stability and preventing nanoparticle release into water. The composite hydrogels exhibited high removal efficiencies (>85%), excellent structural integrity, resistance to biofouling, and consistent performance over multiple adsorption–photocatalysis cycles. These results demonstrate the robustness and practical potential of TiO_2/chitosan-based hydrogels as sustainable materials for solar-driven water treatment applications.

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Cyanobacteria as Green Biofactories: Synthesis of Silver Nanoparticles and their Antifungal Potential against Plant Pathogens.

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Cyanobacteria are versatile photosynthetic microorganisms increasingly recognized as sustainable biofactories for nanomaterial production. Due to their ability to secrete bioactive metabolites, they offer novel material for an eco-friendly alternative to conventional chemical synthesis, eliminating the need for toxic reagents. This study explores the development of cyanobacteria-mediated silver nanoparticles (AgNPs) as a green alternative to chemical fungicides for plant pathogen control. AgNPs were synthesized using three distinct cyanobacterial matrices: cell-free culture medium, extracellular polysaccharides (EPS), and cellular extract. The experimental parameters for the synthesis were optimized by evaluating different temperatures (30°C and 70°C) and reaction times (1, 4, and 24 h). The obtained AgNPs were characterized via UV–Vis spectroscopy and transmission electron microscopy (TEM). Subsequently, the antifungal efficacy of these nanoparticles was tested in vitro against three phytopathogenic fungal species: Diplodia seriata, Gnomoniopsis castaneae, and Fusarium sp. The results demonstrated that cellular extract, combined with higher temperatures and longer reaction times, yielded the highest AgNP concentration. In antifungal assays, mycelial growth was significantly inhibited at 25 ppm of AgNPs, with efficacy varying by fungal species and matrix type. Notably, cellular extract proved to be the superior matrix, providing the best synthesis yield and the most potent inhibitory effects. These findings suggest the potential of cyanobacteria for sustainable AgNPs synthesis and plant disease control.

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Polybutylenesuccinate-co-adipate (PBSA), a versatile, highly biodegradable matrix polymer for composites and nanocomposites with silica and nano cellulose.

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In an effort to reduce global dependence on fossil-based polymers and advance toward more sustainable materials studies on biobased, highly biodegradable polymers for commodities application are relevant. In this contest Poly (butylene succinate-co-adipate) (PBSA) or blends of PBSA and Poly(3-hydroxybutyrate-3-hydroxyvalerate) (PHB-HV) were used as polymeric matrix for production of composites with biomass derived fillers (sea weeds, cereal fibres, wood) and nanocomposites with nano silica and nano cellulose. In particular we deepened how the morphology, geometry, and chemical nature of the nanofillers influence the thermal, mechanical, and barrier properties of PBSA based matrix, as well as its biodegradability. For each nanofiller, three formulations were prepared, containing 1, 2, and 5 wt% of nanofiller, or 10-30% of biomass fillers, respectively. Ultimately the incorporation of natural fillers or nanofillers did not alter significantly the surface hydrophilicity and thermal properties, while improved the oxygen barrier performance and enhanced disintegration, and subsequent mineralization under composting (industrial and home) or environment (soil, water) conditions.

Plant-derived nanovesicles: a new drug delivery system for cancer therapy

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Plant-derived exosomes-like nanovesicles (PDENs) from natural green products have emerged as an attractive nanoplatform in biomedical application.
The goal of our project is to evaluate the potential role of tomato PDENs for drug delivery. PDENs were loaded with acridine orange, a drug used for melanoma phototherapy, through a passive vesicle-drug interaction and active electroporation-mediated mechanism. We tested different electroporation conditions (drug exposure and pulse setting) to find the best drug loading efficiency. Exploiting the fluorescent properties of acridine orange, we evaluated the accumulation amounts in electroporated and non-electroporated PDENs by spectrophotometer and flow cytometer. We observed a higher increase of drug in electroporated PDENs compared to non-electroporated ones. Then, we characterized tomato PDENs by transmission electron microscope and nanoparticle tracking analysis (NTA). Preliminary NTA data showed that electroporation did not significantly affect particle concentration. However, despite an inhomogeneous population of vesicles, mainly at lower drug concentration, at higher acridine orange concentration, the mixture appeared to contain two main subpopulations about 60–70 nm larger than the original vesicles.
We also performed preliminary tests on interaction between melanoma cells and tomato PDENs. Optical microscope observations showed that electroporation favoured the aggregation of PDENs, which require longer interaction time with the tumor cell to allow drug release.
This data, although preliminary, encourages our studies to investigate the interaction of exosomes with the tumor cell by high-resolution microscopic techniques and understand how to plant nanovesicles could favor slow and targeted release in the tumor.

Anthropogenic tracers in Venice Lagoon and in its drainage basin: characterization of small microplastics (< 100 µm) and plastic additives in sediments

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Plastic additives are various classes of compounds used in the plastics industry to produce a wide range of plastic products. Once these objects are in the environment, their breakage can lead to the formation of microplastics (MPs) and fragments of plastic additives, depending on the chemical bonding of these additives to the polymer. Plastic additives can account for up to 70% of an object's mass. Therefore, it is crucial to study the transport pathways and the fate of MPs and plastic additives to better understand emission sources. Sediments are the environmental archive par excellence. Assessing the occurrence of MPs and plastic additives in sediments is fundamental to gaining valuable insights into historical pollution from emerging contaminants of concern (CECs). Investigating the presence of MPs and plastic additives <100 µm to obtain vital information on potential transfer to the food web, with significant implications for environmental and human health (One Health Approach) is essential. As part of BSL 6, a monitoring program investigating microplastics in the Venice Lagoon and its drainage basin, sediments were collected at 8 sites (4 in the Lagoon and 4 in the drainage basin). A rigorous QA/QC protocol was implemented to minimize plastic contamination at every step. A previously developed oleoextraction method was employed as a pretreatment. All the operations were performed in a clean room ISO 7, (plastic-free clean room). A Micro-FTIR was employed for the identification of the particles and their simultaneous quantification (Particles Analysis). A multitechnical approach was employed to cross-validate the results.

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Electrospun PVA Nanofibers Embedding LNPs for Regenerative Medicine: a Proof-of-Concept Study

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Innovative approaches to enhance therapeutic efficacy in regenerative medicine rely on advanced fabrication of biomimetic scaffolds combined with controlled release of non-viral drug delivery systems. In this work, we integrate two industrially scalable and sustainable techniques, i.e. electrospinning and the automated nanoparticle (ANP) microfluidic system, to develop hybrid poly(vinyl alcohol) (PVA) nanofibrous scaffolds for sustained locoregional release of lipid nanoparticles (LNPs). Electrospun nanofibers were synthesized using different PVA concentrations with a monoaxial setup, resulting in fiber diameters between 0.4–0.7 µm. Cross-linking conditions were optimized to improve aqueous stability without affecting fiber dimensions, and scaffold weight loss was evaluated under physiological conditions to assess their potential for LNP release (**Fig. 1A**). Fluorescently labelled LNPs (size <300 nm, PDI <0.3, Z pot. ≈ -30) were formulated with the ANP system and embedded into PVA nanofibers at different concentrations without altering their physicochemical properties. Microscopic (SEM – **Fig. 1B**, confocal) and spectroscopic analyses (FTIR, Raman) confirmed efficient LNP loading. Release studies highlighted the possibility of finely tuning the LNP release rate by optimizing PVA cross-linking conditions. Overall, these results demonstrate for the first time the effective incorporation of microfluidic-produced LNPs into PVA nanofibrous scaffolds as a promising proof-of-concept for multifunctional biomaterials in regenerative medicine. In addition, the use of FDA-approved polymers and lipids with a well-established safety profile, together with a green heat-induced cross-linking process and limited use of organic solvents, further underscores the translational potential of the proposed approach.

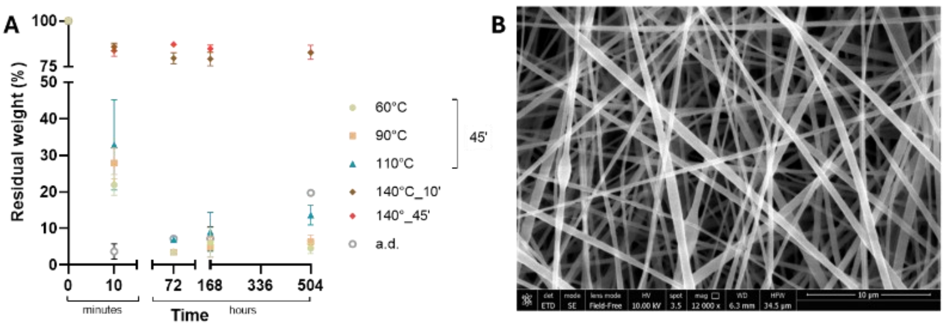

Fig 1. **A**) Degradation studies at physiological conditions of PVA NFs not cross-linked (a.d.) and cross-linked at different conditions. Degradation is expressed in term of residual weight (%). **B**) SEM images of PVA NFs embedding LNPs.

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Eco-anxiety and Urban Health: The Impact of Nature Loss in the Italian Context

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Eco-anxiety is recognized as a significant psychological response to the global climate crisis, manifesting as a state of chronic distress marked by a sense of helplessness and negative anticipation regarding the future. Although not yet categorized as a standalone mental disorder, it is a public health issue interacting with conditions like generalized anxiety and depression. In urban settings, this phenomenon is particularly acute because cities are complex environments where environmental, social, and infrastructural factors converge.

In the Italian context, a primary driver of urban eco-anxiety is the reduction of green spaces and ecosystems. This leads to a decline in ecosystem services, such as pollutant absorption and heat islands mitigation, vital for psychological restoration. Unsustainable urbanization in many Italian cities resulted in nature deprivation, correlated with increased chronic stress and mood disorders. Data highlights that Italian youth are uniquely vulnerable, with approximately 44% of young adults reporting a direct impact of the climate crisis on their mental health. Eco-anxiety in Italy is a rational response to objective risks such as atmospheric pollution, linked to over eight thousand annual deaths.

Mitigating these risks requires the implementation of green infrastructure, such as parks, street trees, and ecological corridors. These interventions are proven to lower cortisol levels and enhance community resilience. Addressing this issue necessitates an integrated policy approach that connects urban planning with public health. Organizations like the WHO and the Istituto Superiore di Sanità advocate for nature-based solutions and intersectoral strategies to increase urban green cover and promote sustainable mobility. Ultimately, by fostering environmental education and civic participation, eco-anxiety can be transformed into a powerful catalyst for change.

Carbon dots enhance UV tolerance via light conversion, photosensitization and nutritional improvement in rice

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As climate change intensifies, rice faces greater risks from unpredictable abiotic stresses, causing a drop in global output. To address these abiotic stresses, developing rice varieties that are tolerant to multiple forms of stress represents a sustainable solution. Among these stresses, UV radiation is a major yield-limiting factor, its high energy induces DNA damage through pyrimidine dimer formation, impairing growth, and photosynthesis. Nano-priming has emerged as an effective strategy to strengthen crop resilience. Carbon dots (CDs) are carbon-based nanomaterials that enhance photosynthesis via light conversion and photosensitization. As an optical amplifier it can transform harmful UV radiation into photosynthetically active radiation that is readily absorbed by plants. In this study, CD-primed rice seedling exhibited improved photosynthetic efficiency and reduced membrane damage under UV stress. This protection was associated with elevated enzymatic and non-enzymatic antioxidants which acted cyclically to remove H_2O_2 and O_2^-, thereby detoxifying ROS. CD priming also improved nutritional status by enhancing mineral uptake and increasing stress-responsive metabolites supporting better growth under stress. Overall, CD-treated seedlings showed superior photosynthetic performance, stronger antioxidant defense, and improved nutritional status, demonstrating carbon dots as effective multifunctional agents for UV stress tolerance in rice.

Keywords: Carbon-based nanomaterials, Carbon Dots, UV stress, Rice

Green Synthesis of Silver Nanoparticles using *Alternanthera tenella* Colla: Multifunctional Bioactivities, Metal Sensing, and Enhancement of Chromium Phytoextraction

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The present study reports the green synthesis of silver nanoparticles (AgNPs) using leaf extract of *Alternanthera tenella* Colla and evaluates their multifunctional biological and environmental applications. Successful synthesis of AgNPs was confirmed by UV–Visible spectroscopy through a characteristic surface plasmon resonance peak at ~450 nm. X-ray diffraction analysis revealed a face-centred cubic crystalline structure with a dominant (111) plane. Fourier-transform infrared spectroscopy indicated the involvement of plant-derived functional groups including hydroxyl, carbonyl and isothiocyanate moieties, acting as reducing and stabilizing agents. Scanning electron microscopy coupled with energy-dispersive X-ray analysis confirmed the morphology and elemental composition of the nanoparticles, with silver as the major constituent along with phytochemical residues. The biosynthesized AgNPs exhibited pronounced concentration-dependent antibacterial activity against *Escherichia coli*, with inhibition zones ranging from 8.83 to 13.6 mm. Antioxidant potential assessed through DPPH, ABTS and FRAP assays demonstrated moderate to strong radical scavenging and reducing activities. AgNPs also showed significant anticancer activity against DLA cell lines (~70% at 200 µg/ml), indicating their potential biomedical relevance. The nanoparticles displayed effective spectroscopic sensing of multiple heavy metal ions, suggesting their applicability in environmental monitoring. AgNP treatment enhanced the phytoextraction efficiency of *A. tenella* under chromium stress, highlighting a synergistic role of nanoparticles in improving heavy metal uptake and tolerance. This study shows that *A. tenella*-mediated AgNPs possess multifunctional properties encompassing antioxidant, antibacterial, anticancer, metal sensing, and phytoremediation enhancing capabilities, supporting their potential use in biomedical, environmental and sustainable nanotechnology applications.

Severe drought intensifies microplastic accumulation in surface waters and sediments of the Amazon River

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Microplastics represent a significant threat to aquatic ecosystems, biodiversity, and human health, particularly during severe drought events. This study compares the impacts of regular droughts in 2021 and 2022 with the severe drought of 2024 in the Amazon River. The results indicate the highest microplastic abundance ever recorded, with 289,000 particles m^{-3} detected at 93.33% of the sampling stations. The mean microplastic concentration during regular droughts was 1,321.43 ± 2,362.88 particles m^{-3}, whereas during the severe drought it increased to 7,075.76 ± 7,799.36 particles m^{-3} (Fig. 1). In sediments, mean abundances were 52.44 ± 75.95 microplastics kg^{-1} during regular droughts and 58.22 ± 50.42 microplastics kg^{-1} during the severe drought (Fig. 2). Higher temperatures and reduced Amazon River water levels appear to be key factors driving microplastic accumulation. During the severe drought, microplastics smaller than 1 mm predominated, whereas larger particles were more prevalent during regular droughts. Blue fibers were the dominant type in the samples, with seven polymer types identified, including polypropylene, polyethylene terephthalate, and polystyrene. Contaminants such as copper phthalocyanine, Naphthol Red, and Indigo Blue were also detected. The presence of microplastics in the Amazon River represents a considerable environmental risk, with the potential to compromise aquatic ecosystem health and alter the region's ecological dynamics. This study provides an important basis for understanding the effects of drought events on microplastic accumulation in environmental matrices of the Amazon River.

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Spatial heterogeneity and local control of microplastic distribution in Amazonian rivers

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The presence of microplastics in large fluvial systems has been widely documented; however, the processes controlling their distribution in tropical environments remain poorly understood. This study evaluated the influence of hydrodynamic factors associated with estuarine systems on the distribution of microplastics in Amazonian rivers. Water samples were collected from seven rivers during two campaigns representative of the rainy and dry seasons, encompassing the rising and falling water phases, both at the surface and throughout the water column, with 40 L filtered per sample. Microplastics were identified through visual sorting and chemically characterized. Paired Wilcoxon tests were applied to compare concentrations among tidal phases, depths, and climatic seasons. Concentrations ranged from 125 to 2050 items m^{-3} among the sampled rivers. Fragments were the most frequent morphology (≈65%), followed by fibers (≈35%), with a higher occurrence of small-sized particles (<500 µm). Blue and red colors accounted for all analyzed particles. Chemical composition revealed the presence of synthetic polymers (40.2%), anthropogenic particles containing dyes or organic contaminants (57.5%), and cellulose (2.3%), with PET, polyester, and nylon being the most recurrent materials. Statistical analyses indicated no significant differences in concentrations between surface and water column, between rising and falling water phases, or between climatic seasons ($p > 0.05$). These results demonstrate high spatial heterogeneity in microplastic distribution, suggesting predominant control by local processes in Amazonian rivers.

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Environmental safety and valorization potential of chars produced from municipal plastic waste in a pilot-scale pyro-gasification process

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Municipal plastic waste represents a growing environmental challenge but also a potential carbon resource within circular economy strategies. Thermochemical conversion through pyro-gasification can transform heterogeneous municipal plastic streams into energy carriers and carbon-rich solid products; however, the environmental safety and functional performance of the resulting plastic-derived chars remain poorly understood, particularly when produced under realistic conditions. In this study, chars were generated from real municipal plastic feedstocks using a pilot-scale pyro-gasification reactor operating at 780–800 °C. Different plastic–biomass blends were investigated, including mixed plastics (PX 50%), high-density polyethylene (PE 90%), polypropylene (PP 90%), and wood chips (WC) as a reference biomass. To evaluate potential risks and application opportunities, physicochemical characterization was combined with biological assays, including genotoxicity assessment using the Ames test (Salmonella strains TA98 and TA100) and agronomic trials on Solanum lycopersicum. The results indicate that feedstock composition strongly influences char performance: although PX and PP chars contained elevated concentrations of Pb, Ni, and dioxins, none of the samples exhibited mutagenic activity, with fold-increase ratios below the mutagenicity threshold. In contrast, agronomic trials revealed a clear dose-dependent response, as low additions of PE char (0.1–0.5%) significantly enhanced plant biomass (up to 175%), whereas PX and higher PE/PP doses induced physiological stress and reduced chlorophyll content. Moreover, microbial assays indicated inhibition of nitrogen fixation and soil bacterial activity in PX-derived materials. Consequently, these findings support a dual valorization strategy, where low-dose PE char may be suitable for agronomic applications, while PX and PP chars could be directed toward industrial uses such as metallurgical reducing agents, ceramic fillers, or bitumen additives.

Keywords: Plastic waste, biochar, Pyrolysis, Gasification, Phytotoxicological risk, Genotoxicity

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Improving crop resilience through nanobiotechnological approaches

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Nanobiotechnology offers promising and eco-friendly solutions that can support the transition to a more sustainable and resilient agri-food system. Engineered Nanomaterials (ENMs) and Plant Growth-Promoting Rhizobacteria (PGPR), in fact, hold the potential to enhance plant growth and protection by restoring soil health and fertility. The study aimed to investigate the morphological, physiological and molecular effects due to the combination of PGPR and nanomaterials on plants of agronomic interest exposed to salt stress: nanometric silicon dioxide ($nSiO_2$) and chitosan-tripolyphosphate (nCh/TPP) were selected, based on their properties in alleviating symptoms of abiotic stresses, to be tested on cherry tomato plants (*Solanum lycopersicum* L.) with a commercial microbial-based product (Mikro-H_2O). nCh/TPP were produced in-house and characterized prior to use. Analysis of the morphological parameters, and the determination of chlorophyll and carotenoids content evidenced the positive contribution of $nSiO_2$, alone or combined with PGPR, in enhancing development and photosynthetic efficiency of the plants. $nSiO_2$ have been administered alone or combined with Mikro-H_2O to soybean plants (Glycine max L. Merr.) subjected to salt stress. The morphological data collected confirmed the influence of $nSiO_2$ in modulating the architecture of the root system also under salt stress conditions. $nSiO_2$ were able to relieve the stress sensed by plants limiting sodium internalization and rising calcium content into the roots. PGPR favored the accumulation of potassium and regulated the uptake of other nutrients. The association nSiO2-Mikro-H_2O enhanced stress defense in soybean plants, restoring the plant photosynthetic activity compromised under saline irrigation, highlighting the potential of these approaches for agricultural applications.

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Integrative use of AMF and calcium oxide nanoparticles enhances mycorrhizal colonization and orchestrates redox homeostasis and photosynthetic performance under NaCl stress in rice

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Strengthening beneficial symbioses offers an effective strategy to enhance plant resilience under abiotic stress. This study investigates the integrative role of arbuscular mycorrhizal fungus (AMF) and calcium oxide nanoparticles (CaO NPs) in mitigating sodium chloride (NaCl) stress in rice (*Oryza sativa* L.) through seed priming and controlled pot experiments. Rice seeds primed with CaO NPs (80 ppm) were grown, followed by inoculation with or without AMF under soil pretreated with NaCl stress. Co-application of CaO NPs and AMF increased root mycorrhizal colonization by 32%, coinciding with 33% higher soil flavonoid exudation ($p < 0.05$) and enhanced calcium uptake. This strengthened symbiotic association improved AMF hyphal proliferation, promoting nutrient and water acquisition and maintaining higher net photosynthetic rates under salinity stress. Redox homeostasis was reinforced, as indicated by elevated reduced and total glutathione (139% and 168%, respectively), while sugar metabolism showed alterations in reducing (110%) and non-reducing sugars (−38%) compared to NaCl-stressed plants. Moreover, co-application treatment improved ionic regulation, increasing Ca^{2+} uptake by 35% and reducing Na^{+} accumulation by 58% as revealed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) analysis. This synergistic impact established a self-reinforcing cycle between nanopriming-induced AMF stimulation and improved physiological performance, resulting in enhanced salt tolerance. Collectively, these findings demonstrate that CaO NP-mediated AMF enhancement reprograms redox and photosynthetic pathways to sustain photosynthetic efficiency and stress adaptation. This integrative bio–nanotechnological approach provides a sustainable avenue for strengthening plant–microbe interactions and improving crop resilience in saline agroecosystems.

Biofertilizer inoculation alters greenhouse gas and volatile organic compound emissions in *Triticum aestivum* seedlings

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Modern intensive agriculture relies heavily on synthetic fertilizers, the use of which causes significant environmental impacts, either emissions of greenhouse gases (GHG) or nutrient leaching to the environment. To mitigate these effects, food production must be developed to be both more efficient and more environmentally sustainable. Bacteria living in symbiosis with crop plants offer a promising means to increase yields, improve nutrient availability, alleviate stress factors, reduce GHG emissions or improve the volatile organic compound (VOC) release from agriculture.

Methane (CH4) oxidizing, nitrous oxide (N2O) reducing and nitrogen-fixing bacteria can contribute to mitigating climate change by enhancing CH4 and N2O emissions and improving nitrogen cycling. These microbes can promote plant growth by increasing nutrient availability and by producing plant growth-regulating hormones. Investigating the effects of these bacteria on plant growth provides insight into the underlying biological mechanisms, which could in the future be used to develop biofertilizers that simultaneously enhance crop productivity and reduce GHG emissions associated with agricultural practices.

In this study we examined the effects of inoculation of two different bacteria strains on *Triticum aestivum* seedlings. Inoculated seeds were grown on MS-agar in a plant growth chamber. During the growth, gas and VOC fluxes were measured to evaluate how bacterial inoculation influences seedling growth and associated climate active gas and VOC emissions. Effect of bacterial inoculation on plant growth, plant growth hormone production and climatic impact will be discussed.

Assessing Nanoplastic Neurotoxicity with the Zebrafish Embryo Model

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Nanoplastics are emerging environmental contaminants of increasing concern due to their persistence, high reactivity, and low environmental concentrations, which make environmental and human risk monitoring and assessment challenging. In this context, zebrafish embryos can help to improve the understanding of the effects and modes of action of nanoplastics. Zebrafish is indeed successfully used in one-health approach studies due to its versatility and advantageous characteristics that make it a suitable multi-endpoint organism. By combining rapid development, transparency, and a well-characterized nervous system in zebrafish embryos, it is possible to study early neurodevelopmental processes *in vivo* and measure their effects from early development through the larval stage in accordance with 3R principles and the European Directive on the protection of animals used for scientific purposes (Directive 2010/63/EU).

Morphological endpoints include survival, hatching, and developmental abnormalities. Together with neurodevelopmental and behavioral parameters such as spontaneous tail embryonic movements (CAT test), sensory-motor responses (stress test), and larval locomotor activity, it is possible to allow a comprehensive evaluation of nanoplastic induced neurotoxicity. In addition, microinjection of fluorescently labeled nanoplastics enables the tracking of their internal fate, tissue distribution, and interactions with developing organs within the organism.

Overall, this approach supports the use of zebrafish embryos as a powerful and ethically sustainable model for assessing the neurotoxicity of nanoplastics, providing an integrative and multi-endpoint tool to investigate their effects and mechanisms of action within a One Health perspective.

Plant Growth-Promoting Bacteria as a sustainable method to enhance drought tolerance in tomato and hemp

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Drought poses a significant threat to global agricultural productivity. Plant growth-promoting bacteria (PGPB) have emerged as a sustainable crop management practice to enhance crop tolerance and physiological performance under water-limited conditions. This study investigated the effects of two PGPB strains, namely *Serratia odorifera* CC7, an ACC-deaminase producer, and *Pseudomonas sp.* PK18, an IAA producer, on two crop species under well-watered and water-stressed conditions. Tomato (*Solanum lycopersicum* L.) and hemp (*Cannabis sativa* L.) plants were inoculated with either individual strains or a mixed consortium (MIX) prior to the onset of water stress. The effects of the interaction between water availability and PGPB treatments were evaluated through measurements of plant growth, gas exchange, chlorophyll fluorescence, abscisic acid (ABA) content, and rhizosphere composition using metabarcoding.

Results indicate that MIX-inoculated plants showed significantly improved their performance compared to the other treatments under water stress. In tomato, MIX-inoculated plants maintained higher photosynthesis, stomatal conductance, and A/C_i curve parameters (A_{max}, J_{max}, V_{cmax}) compared to the non-inoculated plants under severe water stress. Similarly, in hemp, the MIX treatment sustained higher photosynthetic and photochemical efficiency. MIX-inoculated plants also showed increased height and dry mass compared to non-inoculated controls.

These findings highlight the synergistic potential of ACC-deaminase and IAA-producing bacteria in enhancing plant drought tolerance through both physiological and biochemical mechanisms. The study supports the utilization of PGPB into sustainable agricultural practices, particularly in contrasting increasing drought phenomena.

Boosting Photocatalytic Performance in Thin-Film Systems

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Persistent emerging pollutants, including herbicides, antibiotics, and perfluorinated compounds, are increasingly detected at low concentrations in aquatic environments. Owing to an exceptional chemical stability, many of these contaminants pose a serious threat to health and ecosystems and remain resistant to conventional water treatment technologies. In this context, photocatalysis has attracted interest as a promising strategy for their remediation. Despite its intrinsic advantages, however, its implementation remains challenging, mainly due to the use of powdered semiconductors which require catalyst recovery, with the associated risk of particulate release, and are affected by light scattering, which reduces light absorption and complicates process control. Thin-film photocatalysts can overcome these limitations by suppressing scattering and eliminating the need for catalyst recovery, while minimizing the risk of environmental release. Nevertheless, their significantly lower surface area compared to powdered semiconductors limits pollutant–catalyst interactions and, consequently, photocatalytic performance.
To address these challenges, we developed different hybrid polymer–inorganic nanostructured films designed to concentrate pollutants and photons within the catalyst, thereby enhancing photocatalyc performances. This was achieved through different strategies. First, nanostructuring into dielectric lattices allows to increase the local density of photonic states and reduce photon group velocity within selected spectral ranges, resulting in enhanced light absorption and improved kinetics compared to unstructured films. Second, highly adsorbing liquid-crystalline networks were combined with both inorganic and organic photocatalysts to promote selective pollutant adsorption and subsequent degradation. Overall, these hybrid nanostructured thin films provide an effective and scalable solution to enhance photocatalytic performance while enabling water treatment applications.

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A quantum model organism for quantum dots study

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Quantum dots such as CdS and ZnS QDs have been extensively studied using human cells, plants, and unicellular eukaryotes such as *Saccharomyces cerevisiae*. Following preliminary analyses of ZnS QDs effects on wild-type yeast BY4742 growth, Yeast Knock-Out collection, comprising ~4600 haploid mutants deleted in non-essential genes, was screened in the presence of ZnS QDs. Identification of sensitive mutants deleted in genes encoding proteins related to mitochondrial functions addressed to test the relevance of the missed functions and prompted further investigation into the phenotype of the sensitive mutants *sod1Δ* and *glr1Δ* and of hypersensitive mutant *pos5Δ*. This last mutant, which lacks a mitochondrial NADH kinase, showed hypersensitivity specific to ZnS QDs but not to related CdS QDs or zinc sulfate ($ZnSO_4$). Flow cytometry of the wild-type strain and *pos5Δ* mutant detected no significant increase in reactive oxygen species after ZnS QD treatment. RNA-sequencing analyses of the wild-type strain and *pos5Δ* exposed to ZnS QD (or $ZnSO_4$) revealed that ZnS QD exposure selectively modulated genes encoding mitochondrial proteins, metal-binding factors, and intracellular trafficking components. Comparison with published data on CdS QDs identified specific mechanisms involving protein synthesis and degradation.

NAM-based approaches to understand the toxicological profile of ultrafine PM

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Airborne particulate matter (PM) represents a complex environmental mixture associated with adverse health outcomes; however, the mechanistic basis of its effects remains incompletely understood, especially for ultrafine particles, due to the lack of experimental tools sufficiently efficient to predict the hazard and risk for human exposure.
We applied new approach methodologies (NAM), combining cell transformation assay with omics-based technologies, to evaluate the toxicological and transcriptomic responses induced by a real sample of urban ultrafine PM (diameter ≤1 μm), with the aim of understanding the mechanisms underlying these toxicological effects.
BALB/c 3T3 cells were exposed to an organic extract of PM_1 (8 m^3equivalents/dish, 48 h). Cytotoxicity and transformation were assessed using the cell transformation assay (CTA), and parallel transcriptomic analyses were conducted 24 h, 48 h, and 28 days post-exposure. Data were analyzed using ANOVA, PCA, and enrichment analyses to identify the perturbed pathways and processes.
This integrated cell transformation–omics approach demonstrates the capacity to capture early, human-relevant responses to complex environmental mixtures. Urban PM_1 elicited molecular perturbations consistent with non-genotoxic modes of action, particularly immune modulation and cytoskeletal plasticity, which sustain cardiovascular and pulmonary diseases. These findings underscore the efficiency of NAMs to inform about the mode and mechanism of action of ultrafine particles, to guide evidence-based decisions in the regulatory context.

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Biodiversity restoration and nanotechnologies

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The development and use of nanotechnologies may have a potential impact on both human health and the environment. Nanomaterials can provide relevant environmental benefits through the application of innovative treatment and remediation technologies, but at the same time the available scientific data, although not complete, indicate that their applications might be detrimental for biodiversity changes in some cases. For this reason, legislative instruments are needed to certify and legitimize the correctness of techno-scientific procedures and products, regulating and disciplining technical and value-related aspects, defining the limits of cognitive and applicative practices, and determining their social and political implications. In the Italian context, the European Nature Law plays a central role in halting or, at least, reducing the impact of new technologies on human and environmental health. The aim of the legislation is to ensure the conservation, restoration and sustainable use of freshwater and terrestrial ecosystems and their services. The Act focuses in particular on the protection of forests, wetlands, mountains and arid areas, contributing to climate change mitigation and adaptation objectives. The Nature law has the overall objective to improve, the sustainable use of ecosystem services, exploiting the innovative products and services and preserving current and future human health integrity linked to the protection of biodiversity. The requirements set in this legislation can provide a strong support in the management of the risks caused by nanotechnologies, also, taking into account the environmental benefits.

Biochar as nanocarrier of endophytic bacteria for *Helianthus annuus*

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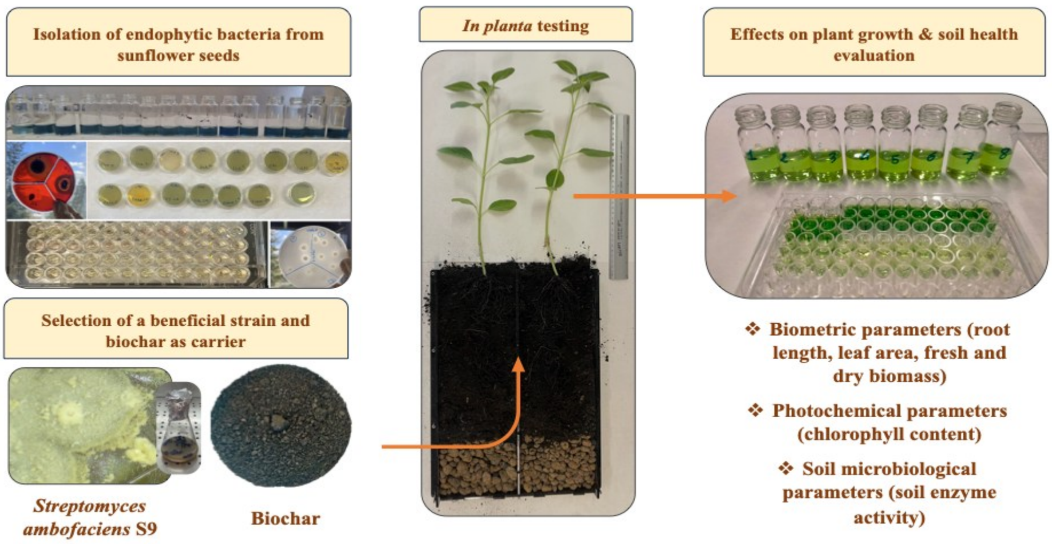
The utilisation of beneficial microorganisms with nanocarriers, like biochar, presents an innovative solution for enhancing agricultural productivity whilst concomitantly reducing reliance on chemical inputs. The present study evaluated the effectiveness of *Streptomyces ambofaeciens* S9, isolated from *Helianthus annuus L.* seeds, in promoting the growth of the latter in a variety of substrates. The selected strain was characterised for indole-3-acetic acid (IAA) production, phosphorus solubilization, and ACC-deaminase activity, mechanisms that render it suitable for agricultural use. The experiments were conducted under greenhouse using a randomized block design and Rhizoboxs. Effectiveness of biochar (Natural Biochar, Silpa Srl) as amender and nanocarrier was tested using peat and peat: biochar mixtures (10:90% w/w), in the presence and absence of bacterial inoculation. Plant growth parameters were evaluated 40 days after sowing. Respect to biochar treatment, inoculation with S9 increased root length by 30%, fresh biomass by 50%, and dry biomass by 35%. Furthermore, a 25% increase in chlorophyll a and a 30% increase in chlorophyll b were observed, indicating enhanced photosynthetic efficiency. Biochar improved substrate properties, while its combination with S9 resulted in more pronounced synergistic effects, evidenced by increased soil microbiological activity and proline levels (1.13 nmol/mg FW), indicative of greater tolerance to abiotic stress. Overall, the integrated use of S9 and biochar at 5-10% w/w represents an effective strategy for increasing crop resilience and the sustainability of production systems. The activities were carried out as part of the project "Bio.SOUTH – Combined fertilization wgith BIOchar to sustain mOUnTain production of *Heliantus annus*.



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Development of Biochar & Graphene Oxide Bio-Based Composite Adsorbents for CUPs Removal

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The increasing occurrence of contaminants of emerging concern (CECs), including per- and polyfluoroalkyl substances (PFAS) and pesticides including Current Use Pesticides (CUPs), in aquatic environments poses significant challenges due to their persistence and limited removal by conventional treatment technologies. This study investigates the development and adsorption performance of bio-based and nanostructured composite adsorbents for the effective removal of CUP from water.
Bio-based Composite materials were synthesized using combinations of graphene oxide, Fe_2O_3 nanoparticles, biochar, and biopolymer matrices through both physical mixing as well as chemically assisted routes involving in-situ nanoparticle formation and crosslinking. Batch adsorption experiments conducted at environmentally relevant concentrations (50–200 ng/L) to evaluate the effects of pH, adsorbent dosage, contact time, and initial contaminant concentration on adsorption efficiency. Adsorption equilibrium was typically achieved within 18–24 hours.
Material characterization using (TEM) revealed sheet-like morphologies with surface ruffles, resulting in increased surface area and improved adsorption performance. XRD analysis confirmed the crystalline phases and successful incorporation of iron oxide within the composite matrix. Zeta potential measurements were used to assess surface charge behavior as a function of pH, providing insight into electrostatic interactions between the adsorbent surface and charged contaminants. The results indicate that negatively charged composite surfaces favor the adsorption of cationic contaminants at higher pH, while adsorption of anionic species is enhanced under acidic conditions. (FTIR-ATR) analyses elucidate surface functional groups and morphological features involved in adsorption mechanisms. Overall, the results demonstrate that the synthesized composite adsorbents exhibit strong potential as efficient, sustainable, and low-cost materials for the removal of CUP from water. This work supports the development of advanced adsorption-based treatment strategies for emerging contaminants in water and wastewater systems.

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The Hidden Life of Wheat Soils

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Wheat (**Triticum aestivum L.**) production increasingly requires reconciling productivity with environmental sustainability. While organic farming is promoted to enhance soil biological functioning and reduce greenhouse gas (GHG) emissions, the combined effects of wheat genotype, agronomic management, and environmental conditions on soil microbial functional diversity remain poorly understood. This study proposes an integrated approach to investigate genotype × management interactions, focusing on microbial metabolic fingerprinting under organic management. The experiment was conducted at two Italian sites with contrasting pedoclimatic conditions, where three wheat cultivars (Bologna, Nogal, and Sieve) were grown under conventional and organic systems. Soil samples were collected at tillering, flowering, and maturation to capture temporal shifts in microbial activity driven by plant development.

The core analysis utilized Community-Level Physiological Profiling (CLPP) via Biolog EcoPlates™ to characterize the functional metabolic diversity of soil microbial communities. Activity was quantified through Average Well Colour Development (AWCD) and substrate utilization patterns. To validate these results, the study integrated soil respiration tests for microbial oxidative activity, in situ GHG flux measurements using portable gas analyzers, and satellite-derived climate and soil moisture data to define site-specific hydrological regimes. The integration of CLPP, respiration, GHG fluxes, and satellite data enables a multi-scale assessment of soil biological functioning. This framework allows for the evaluation of cultivar-specific responses to organic management while accounting for environmental constraints, offering a robust approach for identifying wheat genotypes better suited to sustainable, low-input agricultural systems.

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What are we missing? Plastic additives in a drinking water source revealed by non-targeted screening

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The quality of water intended for human consumption is monitored according to the European Directive 2020/2184. Although the directive includes a wide range of chemical compounds, including some emerging contaminants, it is not feasible to routinely monitor the presence of every chemical potentially occurring in water bodies. Among these, plastic additives (PAs) represent a class of emerging contaminants of growing concern. PAs are intentionally added to polymers to confer specific properties and, being not chemically bound to the plastic matrix, they can be continuously released into the environment throughout the life cycle of plastic materials, posing potential risk to human and environmental health.

This study investigates the occurrence of plastic additives in the Canale Unico Acque Irrigue (CUAI), a canal conveying water from the Sile River to the Ca' Solaro drinking water treatment plant. Winter samples (December–February) were analyzed by HPLC-HRMS applying Non-Targeted and Suspect Screening approaches.

The results revealed a recurrent and consistent presence of several PAs over the sampling period, with plasticizers being the most frequently detected compounds. These findings highlight the relevance of advanced screening approaches to uncover overlooked contaminants in water bodies used for drinking water production and underline the need to expand current monitoring strategies beyond regulated substances.

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Untargeted UHPLC-HRMS combined with multivariate statistics to reveal the effect of nanoparticle-enriched biochars on metabolomics of basil

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Advanced mass spectrometry-based techniques are providing new insights into the complexity of plant metabolism by identifying primary and secondary metabolites that play a crucial role in processes such as plant growth, stress responses, and nutritional value. Plant metabolomics relies on a multidisciplinary approach aimed at agricultural improvement, drug development and sustainable ecosystem management. As untargeted metabolomics evolves toward big data science, proper multivariate statistical tools are required to handle high-dimensional omics data and extract reliable information on metabolic processes.

In this study, untargeted metabolomics by ultra-high performance liquid chromatography-electrospray ionization Orbitrap high-resolution mass spectrometry (UHPLC-ESI Orbitrap HRMS) was applied to investigate the metabolome of basil (Ocimum Basilicum L.) in response to sustainable treatments, i.e., the addition of nanoparticle-enriched biochar alone and in combination with two different consortia of commercial plant growth promoting microbes. Field experiments were carried out to test three fertilization treatments as well as the control (untreated), with two harvests to account for variability related to different plant growth phases. The MS acquisition mode was Data Dependent Analysis (DDA, Top 4), implementing a scheduled exclusion list created from procedural blanks.

UHPLC-HRMS data analysis was performed by processing the raw data by Compound Discoverer 3.3 software (Thermo Fisher Scientific); after alignment and Quality Control (QC) area correction, features were initially filtered based on signal-to-noise ratio, analytical quality parameters, availability of the MS/MS spectrum in DDA acquisition and univariate p-value (ANOVA), shortlisting hundreds of features. ANOVA-simultaneous component analysis (ASCA) was applied as a multivariate extension of ANOVA particularly suitable when dealing with a high number of correlated variables as in metabolomic studies, often exceeding the number of samples [3,4]. This was feasible because the multivariate data were acquired according to a balanced experimental design at two factors (fertilization and harvest time). The significance of the fertilization factor was assessed by separating the variance attributable to its effect from the total variance, obtaining a p-value lower than 0.001. The score plot of the ASCA model for the fertilization effect allowed us to distinguish and separate the four groups using three Simultaneous Components (SCs). Further feature selection was carried out by considering the most significant loadings associated with the three SCs; these compounds were then submitted to annotation. The differentiation of the metabolic profile was mainly driven by sugars, amino acids, vitamins and essential nutrients, reflecting the impact of soil amendment and its combination with microbial consortia on the bioactive profile and overall quality of basil.

The multivariate data analysis approach applied in study to identify biomarkers able to differentiate among treatments highlights the triggered metabolic pathways, underpinning the decision-making process for a more nanobiotechnology-mediated sustainable food system.

This work was supported by the project by Emilia Romagna Region under the ERDT projects “SAFER” and “STREAM2B” (PR FESR 2021-2027 program -Action 1.1.2) with the support of European Union.

Circular Economy and Sustainable Agriculture: The Cleopatra project Nanohydroxyapatite from biowastes as smart nanofertilizer

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The PRIN project "Cleopatra" (October 2023–February 2026) aims to advance nano-enabled agriculture by developing innovative strategies for nanofertilization. The goal is to improve nutrient use efficiency and reduce the environmental impact of conventional fertilization practices. Cleopatra specifically focuses on the use of waste-derived nano-hydroxyapatite (nHAP), which is further engineered through urea functionalization and integrated with phosphate-solubilizing bacteria (PSB). This results in a multifunctional nano-hybrid fertilizer designed for maize (*Zea mays*) cultivation under controlled greenhouse and field conditions.

CNR-NANOTEC is responsible for the design, synthesis, and physicochemical characterization of nanostructured materials, with emphasis on optimizing the interfaces among nHAP, urea, and PSB. The University of Bolzano (UniBZ) is investigating the effects on soil fertility and microbial community dynamics, testing a specific PSB strain (*Pseudomonas alloputida*) in combination with nHAP, and evaluating plant biochemical, physiological, and molecular responses, including nutrient interactions and the expression of phosphate transporter genes. The University of Udine (UniUD) is studying the behavior of nHAP within the soil profile, N and P release kinetics, and the physiological and agronomic performance of maize by integrating photosynthetic traits, growth parameters, and elemental distribution.

In this framework, CNR is focusing on nHAPs synthesized from chicken bones calcined at 300 °C ($nHAP_{300}$) and 700 °C ($nHAP_{700}$), which exhibit distinct physicochemical properties. UniBZ has demonstrated that nHAPs, particularly nHAP700, enhance phosphorus use efficiency, promote maize growth, and induce phosphate transporter gene expression at levels comparable to conventional phosphorus fertilizers. UniUD has observed reduced P losses during percolation tests when using nHAP compared to traditional fertilizers. Overall, Cleopatra integrates material engineering with soil–microbe–plant interactions to evaluate agronomic efficiency and sustainability relative to conventional fertilization systems.

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Laboratory Investigation of the Subsoil Transport of Sulphur Nanoparticles used in Viticulture

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Agrochemicals, despite their negative effects on human health and environment, are a necessary support to crop production. Increasing pressure from powdery mildew and other diseases is being observed in vineyards, driving the need for novel tools for addressing grapevine diseases. Nanostructured sulfur-based materials have shown strong antibacterial and antifungal properties, and showed promises to this aim. However, several aspects connected to their use still require investigation, including those connected to their environmental impacts. In this work, we focused on the mobility and fate in soils of five types of sulfur nanoparticles (SNPs), including commercial and non-commercial products, expected to be applied in aqueous suspensions as fungicides in winegrowing. The research specifically analyses at the laboratory scale their colloidal stability and transport in porous media in column transport experiments, conducted in saturated and unsaturated conditions.

First, the five SNPs were characterized to determine their size, morphology, and colloidal stability. Subsequently, transport experiments were carried out by injecting the nanoparticle suspensions into sand-packed columns. Breakthrough curves and retention profiles were measured, and the experimental results were interpreted using modeling tools for colloid transport, namely MNMs (www.polito.it/groundwater/software/MNMs) and HYDRUS-1D (https://www.pc-progress.com/en/Default.aspx?hydrus-1d) to estimate the parameters describing attachment and detachment kinetics.

The results showed that SNPs are retained more strongly, particularly near the column inlet, compared to commercial formulations, with no significant differences between saturated and unsaturated conditions. Moreover, modelling findings indicated that first-order detachment coefficients generally exceeded the attachment ones, suggesting that SNPs are more easily released from sand grain surfaces.

Microbial and Nanoparticle Mediated Enhancement of Phytoextraction in *Alternanthera Tenella* Exposed to Multi-Metal Stress

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Heavy metal contamination poses a serious environmental concern that necessitate sustainable remediation practices. Phytoextraction using plants is an eco-friendly solution, though its efficiency is often limited under high metal stress. The present study investigates the potential of Alternanthera tenella for enhanced phytoextraction in a consortium of cadmium (Cd), chromium (Cr), lead (Pb), and aluminium (Al) through microbial- and nanoparticle-mediated strategies. Silver nanoparticles (AgNPs) of average size 10-50 nm were green synthesized using leaf extracts of A. tenella. AgNPs were characterized and exhibited stable physicochemical properties along with metal-sensing and bioactive characteristics. A controlled experimental design included four treatments: untreated plants (control), plants exposed to the metal consortium, plants treated with metals and metal-accumulating rhizospheric microbial consortia and plants treated with AgNPs. Comparative analysis showed that plants subjected to metals alone exhibited reduced growth and limited metal uptake due to phytotoxic effects. Microbial-assisted treatments improved plant tolerance, biomass and metal accumulation, indicating enhanced metal mobilization and stress mitigation. AgNP-treated plants showed the highest enhancement in metal uptake and plant performance, suggesting improved metal bioavailability and translocation. Both microbial and nanoparticle assisted approaches proved to be more effective than plant only metal treatments, with AgNPs showing the greatest enhancement of phytoremediation potential. The findings highlight the synergistic role of green nanotechnology and biological interventions in advancing sustainable multi- metal phytoremediation strategies.

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Towards New approach methodologies for Micro- and Nanoplastics Hazard Identification: comparative insights on Polystyrene and Biodegradable particles

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Micro- and nano-plastics (MNPs), which result from the fragmentation processes of plastic waste, are solid polymers with an average size of <5 mm and <100 nm, respectively.

MNPs are persistent environmental contaminants that have colonized every ecological niche. They are detected worldwide in marine and terrestrial ecosystems. The presence of these pollutants in the environment is an emerging risk that requires urgent risk assessment. New Approach Methodologies (NAMs) are one of the first choices to generate the information to improve mechanistic understanding of nanoscale processes, as they can support chemical risk assessment. This study investigated the biological effects of polystyrene (PS-NPs) and polycaprolactone (PCL-NPs) nanoplastics (NPs) using complementary *in vitro* intestinal barrier models and the *in vivo* 3R-compliant *Caenorhabditis elegans (C. elegans)* model. Cytotoxicity, DNA damage, oxidative stress, internalization, and paracellular permeability were evaluated in the *in vitro* models. In *C. elegans*, the analyzed endpoints included oxidative stress response and locomotor behavior. Results indicated that the PS-NPs induced DNA damage and barrier impairment *in vitro*, whereas PCL exhibit comparatively lower biological impacts. Consistent findings emerge in the *in vivo* model, where PCL caused milder effects than PS-NPs, suggesting that chemical characteristics of biodegradable polymers play a key role in determining the biological impact of NPs, underscoring the potential advantages of biodegradable nanomaterials for safer environmental and biomedical applications. The study aims to evaluate human health risks resulting from exposure to MNPs using a One Health approach within the BioPlast4SAFE project (PNC Ministry of Health CUP: I55I22000510001).

Adsorption and Controlled Release of Functionalized Metal Salts in Zeolites with Different Porosity for Agricultural Applications

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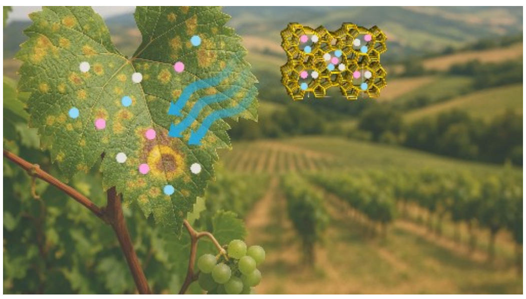
The application of zeolites in agriculture has attracted growing interest as a means to enhance nutrient use efficiency and reduce the environmental impact associated with conventional fertilization and phytosanitary practices. Thanks to their defined porosity, high cation-exchange capacity and chemical selectivity, zeolites are effective materials for the adsorption, retention and controlled release of ionic species in soil environments. Their strong affinity for nutrient cations and metal ions with antimicrobial activity makes them suitable for multifunctional agricultural applications. This study focuses on the adsorption and controlled release of functionalized metal salts, such as $Cu_3(PO_4)_2$, $Zn(NO_3)_2$ and $CuSO_4$, within microporous zeolites selected on the basis of their framework structure and ion-exchange properties. Zeolitic matrices including Beta, Mordenite and ZSM-5 are comparatively evaluated in terms of metal loading efficiency, ion affinity, retention capacity and release profiles under agronomically relevant conditions. Particular attention is paid to the relationship between pore architecture, crystallographic structure and metal release kinetics. This work focuses on the development of an innovative controlled-release system capable of delivering essential micronutrients (Cu^{2+}, Zn^{2+}, Mn^{2+}, Ni^{2+}) while simultaneously providing protection against fungal pathogens, with specific reference to *Plasmopara viticola*, the causal agent of grapevine downy mildew. By combining the nutritional and phytochemical effects of selected metal ions with the reservoir function of zeolites, the proposed hybrid materials aim to extend the availability of active species, reduce application frequency and limit environmental dispersion. This approach represents a sustainable alternative to conventional copper-based treatments and offers new perspectives for low-impact plant protection and precision agriculture.



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Novel Synthesis of Carbon Dots from the Defensive Secretion of *Luprops tristis*: Characterization and Evaluation of Antimicrobial, Anticancer, and Antioxidant Activities

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We have developed a straightforward and eco-friendly one-step hydrothermal synthesis method to produce carbon dots (CDs) derived from a common beetle species Luprops tristis (L. tristis), a novel source among various green sources of CDs. These CDs exhibit robust fluorescence, making them suitable for bioimaging, biosensors, and antibacterial treatments. They demonstrate high stability without the need for surface passivation additives, and their versatile surface groups enable compatibility with bioanalytical techniques and solubility in hydrophilic solvents. The UV-Vis spectrum shows an absorption peak at 225 nm, corresponding to π-π* transitions of the C=C bond. FTIR spectra highlight functional groups involved in the formation and reduction of these CDs, while Raman spectroscopy confirms the D and G band of CDs. These characteristics position CDs as promising biomedical tools for monitoring human health. Furthermore, the synthesized CDs have demonstrated effective antibacterial properties against both Gram-positive and Gram-negative bacteria, antioxidant properties, and anticancer properties towards DLA cells. Overall, the attributes of these environmentally friendly carbon dots suggest they can be readily scaled up for large-scale production without harmful chemicals, highlighting their potential in sustainable biomedical applications. Although carbon dots have been synthesized from various green sources documented in the literature, deriving carbon dots from insect secretions has not been recorded. This study presents a novel and innovative approach by synthesizing carbon dots from insect secretions, revealing significant potential for biomedical applications.

Keywords: L.tristis, Carbon dots, Antibacterial, DLA, DPPH

Polymethylmethacrylate nanoplastics mitigate cadmium effects on human mesenchymal stromal cells

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Plastic pollution is a global warning due to the disruption in micro and nanoplastics (NPs) in the environment. NPs enter the food chain and accumulate in body tissues. Furthermore, NPs can adsorb other pollutants, such as heavy metals, potentially enhancing their toxic effects. Both NPs and cadmium may promote bone loss triggering oxidative stress which hinders osteoblastic differentiation of mesenchymal stromal cells (MSC). This work aims to evaluate the effects on human MSC of two commercial NPs, such as the well-studied polystyrene (PS) NPs and the thus far under-investigated polymethyl methacrylate (PMMA) NPs in association with cadmium.

Human bone marrow MSC were treated with both NPs in the presence or in the absence of cadmium sulfate (IC50=125ng/ml,). PMMA- and PS- NPs were characterized using Zetasizer (PMMA: Z potential = -36.9±4.68mV, aggregate size = 385.9±69.32nm; PS: Z potential = -8.75±28.7mV, aggregate size = 55.48±13.41nm). PS-NPs do not affect MSC viability even at the highest concentration (200μg/ml), while PMMA-NPs dose-dependently lowered cell growth. Cells treated with PMMA-NPs, but not PS-NPs, displayed high vacuolization. To determine NPs effects on cadmium toxicity, cells were incubated with cadmium, at the IC_{50}, in the presence of increasing concentrations of either NP. While PS-NPs did not alter cadmium effects, high doses of PMMA-NPs increased cadmium-treated MSC viability, thus exerting a protective effect.

In conclusion, NPs with different compositions not only exhibit different toxicity on MSC but, noteworthy, can distinctly modulate the toxic effects of heavy metals. Further experiments will study the mechanism behind the protective effect of PMMA-NPs on cadmium toxicity.

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Soot-Derived Carbon Aerogels as Sustainable Porous Platforms for Adsorption Applications

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The upcycling of combustion-derived carbonaceous by-products into functional porous materials represents a promising strategy for the development of sustainable adsorbents. In this contribution, we present the fabrication of lightweight, monolithic aerogels based on soot-derived carbon particles embedded within a biopolymeric matrix. The work emphasizes the aerogel architecture, its hierarchical porosity, and the role of carbon inclusions in tailoring structural and surface-related properties.

The proposed approach exploits soot as a low-cost, nanostructured carbon source, which is homogeneously integrated into a chitosan-based framework to obtain mechanically stable, highly porous aerogels. The resulting materials exhibit interconnected macroporosity combined with carbon-rich walls, a morphology that is particularly attractive for mass transport–driven processes.

Preliminary investigations indicate that the presence of soot significantly enhances the functional performance of the aerogels, highlighting their potential as versatile adsorption platforms, for either air or water remediation

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Nanoengineered surfaces to reduce adhesion of microbes

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Bacteria and fungi can colonize and survive on surfaces for extended period time, forming a biofilm that increases their protection and effectiveness even after the use of disinfectants. This, by contact, contributes to the transmission of infectious diseases. The hand represents a powerful vehicle of transmission since it contacts these surfaces which can be colonized by pathogens such as *P.aeruginosa*, *S.aureus* and *C.albicans*. Biofilms formation represents a problem in healthcare, as they allow pathogens, which adhere to the surfaces of medical devices, to become more resistant to the human immune system and antibiotics. This study aims to produce innovative, sustainable, anti-proliferative and anti-adhesion surfaces, while increasing efficiency in the molding process. Mold inserts were textured by using ultra-short laser, subsequently polymeric samples (IXEF and TPU) were produced replicating the textures of the mold on the sample surfaces. Polymeric substrates were coated with alumina nanoparticles functionalized with stearic acid through spray deposition to obtain hydrophobic coatings. The resulting surfaces were tested with the most common pathogenic microorganisms, as *C. albicans* and *P. aeruginosa*, and subjected to microbiological, molecular, and microscopic analyses to test their adhesion and proliferation. These assessments were able to identify the best surface treatment, that allowed a significant lowering of the pathogens' adhesion capacity. Next, the cleaning and disinfecting capacity of an artificially contaminated surface will be tested. These results are obtained in the framework of the project SAF-ER. Project implemented thanks to European funding from the Emilia-Romagna region (**CUP** E17G22001630003).

Keywords: adhesion; surfaces; microorganisms

Biochars derived from three agri-food residues beyond soil improvers. Morphological, physiological and molecular effects on tomato (*Solanum lycopersicum* L) and wheat (*Triticum durum* Desf) plants

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The utilization of agri-food industry residues to produce soil improvers represents an opportunity to reduce waste and chemical fertilization in agriculture. Biochar is a carbon-rich material derived from pyrolysis or pyrogasification of biomasses that offers great opportunity as an amendment and soil improver in agriculture because of its capacity to retain CO_2, water, and nutrients, protect and encourage proliferation of rhizospheric microorganisms. In this study, three different biochars were produced from agri-food industry residues: olive pomace, vinasses, and tomato peels. Biochar derived from vinasses showed the highest N, P, and K content (respectively 12000, 4200 and 11700 mg /Kg^{-1}. The three biochars were applied to tomato (Solanum lycopersicum cv Heinz 1301) and wheat (Triticum. durum cv Svevo) in a greenhouse experiment at three concentrations (0,1-0,25-0,5% w/w) to assess their effect on plant growth, physiology, and transcriptome as well as rhizospheric soil health. Plant growth was estimated in terms of biomass (canopy cover, weight, and length of roots and stems), plant physiology (transpiration rate and chlorophyll content), and plant transcriptome analysis on the expression of genes involved in growth and hormone-regulated pathways. Soil health was estimated by assessing the total countable microorganisms and key enzymes involved in nitrogen mineralization (arylamidase), cellulose degradation (β-glucosidase), and phosphorous release (phosphatases). The biochars did not significantly affect the chlorophyll content, the transpiration rate, or total countable microorganisms, but all enhance the activity of arylamidase in tomato with increases of up ten-fold compared to the control exerted by biochar derived from vinasses. The activity of β-glucosidase is enhanced by the same biochar at 0.5% in both plants, with an increase of 20.4% in tomato and 29.5% in wheat with respect to the control. The effect on phosphatase activity is different in the two plants: in tomato, it is enhanced by biochar derived from tomato peels at 0.5% (+27.5%) while in wheat by biochar derived from olive pomace at 0.5% (+45.4%). A concentration of 0.5% biochar derived from vinasses exerts a positive effect on plant growth, increasing the canopy cover in tomato (+125.5%) as well as length of stems (+13.5%), fresh and dry weight of roots (+97.8 and 57.0% respectively) and stems (+41.5 and 44.3% respectively) in wheat. This is consistent with modulation of genes involved in plant growth and development, such as cell biogenesis, nutrient transport, hormone signaling, and stress response observed in both plants in the presence of this biochar.

Microplastic contamination in the Amazon River Delta: a first integrative approach

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The problem of microplastic contamination extends beyond the mere presence of particles in the environment, posing risks to the ecological integrity of aquatic ecosystems, particularly in sensitive, highly productive, and biodiverse regions like the Amazon River delta. This study is the first to comprehensively investigate microplastics in different environmental compartments, such as surface water, the water column, and bottom sediments, while considering tidal variations in the Amazon River delta. Sampling was conducted during two rainy-season campaigns in 2023 and 2024 at five stations. The highest concentrations were observed in surface waters, especially in the northern and southern channels near Macapá (2133.33 ± 425.25 and 983.33 ± 368.56 microplastics·m^{-3}, respectively). Concentrations in the northern channel increased during high tides and decreased during ebb tides, affecting both surface water and the water column. Microplastic volume, area, and particle size progressively increased from surface waters to sediments, suggesting higher accumulation in deeper compartments. Most particles were fibers (51%) and fragments (48%), predominantly blue (50%) and red (25%). The main polymers identified were polyethylene (35%), polyester (33%), and polyethylene terephthalate (15%). Additionally, associated dyes, mainly blue (38%), indigo (19%), and red (7%), reflect industrial additives and potential toxicity. The presence of microplastics across multiple environmental matrices in the Amazon River delta indicates a growing threat, with potential transport to adjacent waters and the Atlantic Ocean. These findings provide critical insights into the concentration, distribution, and characteristics of microplastics, emphasizing the urgent need for strategies to mitigate plastic contamination and protect the Amazon ecosystem.

More than just fish: Experimental Design for microplastic analysis in lipid-rich food

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The presence of microplastics (MP) in food raises concerns about human exposure, due to the lack of standardized analytical methodologies for their detection in complex food matrices. Currently, MP risk assessment is based on detailed knowledge of the chemical nature of polymers, with micro-Fourier transform infrared spectroscopy (μFTIR) being one of the most reliable techniques for this purpose. However, its application is often compromised by the presence of residual organic matter, especially in lipid-rich foods.

In this study, a Design of Experiment (DoE) approach was applied for the first time to develop and optimize an analytical protocol for the extraction and purification of MPs from lipid-rich food matrices. Fish species with different lipid contents, namely salmon, tuna, and cod, were selected as representative matrices. The digestion protocols were optimized by systematically studying the effects of solvent type, and digestion time and temperature using experimental design. The performance of the method was evaluated in terms of recovery percentage and carbonyl index, the latter used as an indicator of residual lipid interference. The screening phase and response surface matrices allowed the identification of optimal digestion conditions ("sweet spot") for each fish species, highlighting the influence of lipid content on extraction efficiency. Enzymatic digestion was found to be optimal for high-fat matrices, while alkaline digestion was found to be more suitable for low-fat samples.

The optimized protocol demonstrated high recovery and compatibility with μFTIR analysis, supporting accurate polymer identification. This DoE-based approach provides a reliable and sustainable strategy for MP analysis in food, contributing to improved standardization and risk assessment.

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Biochar as a Driver of the Life-Supporting Capacity of Agricultural Soil: Effects on Soil Mesofauna

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Compared to other soil types classified by land use, agricultural soil has the lowest capacity to support life. Different soil amendments can influence soil biota, change the conditions of the environment, and affect soil fauna through their application, highlighting the importance of selecting appropriate amendments. In line with the goals of Soil Deal for Europe project DeliSoil financed through Horizon Europe program and the project from PR-FESR Emilia-Romagna 2021-2027 program, C+AgroForER, the effects of three different types of biochar (tomato, grape and olive) were examined. Their influence on soil biological quality, microarthropod community structure, ecosystem functions and feeding habits was assessed in the first 10 cm of soil under tomato cultivation. The results show no significant differences between biochar-amended soils and the control in terms of soil biological quality based on arthropods (QBS-ar). Furthermore, analysis of the community structure reveals no significant differences in richness, while abundance is significantly lower in soils treated with grape biochar compared to control. Tomato and olive biochar show no significant differences. No significant differences were observed in alpha diversity (Shannon index) for population, nor in ecosystem services. Regarding feeding habits, grape biochar is marginally significantly lower ($p=0.049$), whereas tomato and olive char show no significant differences with control. Concerning beta diversity, olive biochar had the greatest influence across the field based on richness (Whittaker index), while the control has the lowest, indicating the potential of the treatments to increase field biodiversity. The Bray-Curtis index showed the highest similarity in abundance between tomato char and control.

Overall, the results suggest that tomato and olive char have the greatest potential to preserve field conditions while also offering some potential to increase microarthropod biodiversity.

Keywords: QBS-ar, alpha diversity, beta diversity, richness, abundance

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Nascent g-C_3N_4 and micronutrient doped g-C_3N_4 priming enhances abiotic stress tolerance potential in *Oryza sativa* L.

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The effects of abiotic stress on plants are complex and involve physiological, biochemical, and molecular pathways. Around 3-5% of the solar UV radiation reaching the Earth's surface is UV-B, it can highly influence plant biology. As rice is not completely shaded, direct UV-B can damage tissues exposed to sunlight, causing DNA damage and alter molecular processes.

To develop sustainable strategy for stress resilience, we explored zero-toxic priming agents based on graphitic carbon nitride (g-C_3N_4), which were doped and modified to Fe/(g-C_3N_4). Under UV-B stress, seeds primed with these nanomaterials showed an increased rate of seed germination, shoot length, and other key growth parameters as compared to those exposed to UV-B stress alone. Primed seedlings analysed for various physiological and biochemical parameters revealed enhanced antioxidant enzyme activity, reduced oxidative damage, and improved stress tolerance in primed seedlings. Priming induced significant changes in yield-related attributes like panicle length, number of filled grains per panicle, and 100-grain weight in treated plants. In addition, metabolomics analysis revealed changes in metabolite accumulation which are significantly contributing to stress tolerance. Gene expression analysis revealed the key genes and pathways involved in antioxidant defense and stress tolerance. Altogether, in the face of changing climatic conditions, the present findings assure priming with Fe/(g-C_3N_4) nanoparticles as a sustainable strategy for enhancing crop resilience against UV-B stress, which can improve crop productivity and nutritional quality.

PLGA–Mannose Nanoparticles Produced by Scalable Microfluidics for Cancer Therapy

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Poly(lactic-co-glycolic acid) (PLGA) is a biocompatible and biodegradable polymer widely used in drug delivery systems and approved for clinical use by both the FDA (Food and Drug Administration) and the EMA (European Medicines Agency). Owing to its established safety profile and versatility, PLGA represents an ideal platform for the development of nanomedicine formulations. Its ability to protect bioactive molecules, prolong systemic circulation and allow surface functionalisation for ligand-mediated targeting makes it highly attractive for pharmaceutical applications. In this project, PLGA is employed to formulate nanoparticles loaded with mannose, a natural monosaccharide that has shown promising radiosensitising properties in tumour models by disrupting cancer metabolism. However, free mannose exhibits high water solubility and rapid renal clearance, resulting in a short plasma half-life. Encapsulation within PLGA nanoparticles is therefore proposed to overcome these pharmacokinetic limitations and enable targeted delivery.

Two nanoparticle production methods were optimised: double emulsion and microfluidics. The microfluidic approach (Fig.1) demonstrated superior performance, producing nanoparticles with a mean diameter below 200nm, high homogeneity (polydispersity index<0.15), a stable negative surface charge (~–30mV) and significantly higher mannose loading (up to 40%), while also offering greater potential for industrial scale-up. Stability studies confirmed that the formulation maintained its physicochemical properties for at least one month without cryoprotectants. Importantly, *in vitro* studies demonstrated efficient cellular uptake and significant antitumour activity in cellular models.

The combination of FDA and EMA-approved PLGA, cost-effective components, and an automated, continuous microfluidic production process positions PLGA-mannose nanoparticles as a scalable and relevant innovation in cancer therapy.

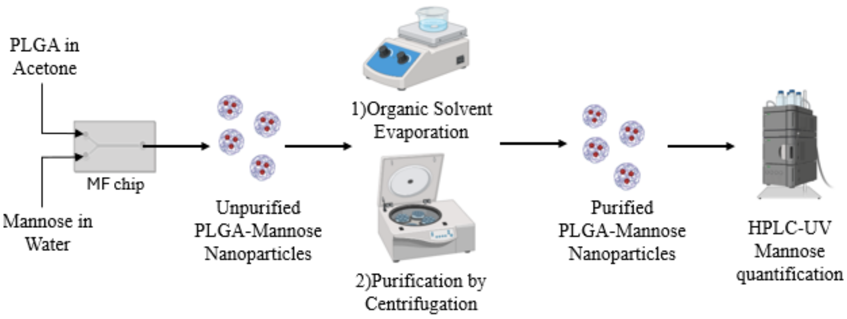

Figure 1: Workflow of nanoparticle production via microfluidics (MF).

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Abundance, characteristics, and export of microplastics in urban channels of Central Amazonia, Brazil

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Plastic pollution is currently one of the greatest global environmental challenges, requiring urgent interventions due to its negative impacts on the economy, infrastructure, ecosystems, and society. In addition to larger plastic debris, which poses direct risks to aquatic and marine fauna, microplastic particles (<5 mm) represent an even more critical threat because of their persistence, transport capacity, and potential for accumulation across different environmental compartments. This study constitutes the first investigation of the occurrence and characterization of microplastics in surface waters and sediments of urban channels in Central Amazonia, considering both spatial (different channel sections) and seasonal variations. The mean concentration of microplastics in surface waters was 333 ± 598 particles m^{-3}, with higher values recorded during the rainy season (Fig. 1). The Caracaraí Channel is estimated to contribute microplastic exports to the river that are 9.334 and 1.697 times greater during the dry and rainy seasons, respectively. In sediments, the mean abundance was 53 ± 52 particles kg^{-1} dry sediment, remaining relatively homogeneous among sections and across seasons (Fig. 2). In both environmental matrices, particles larger than 1 mm predominated, with blue fibers being the most common type. Regarding chemical composition, polymers such as polystyrene, polyethylene terephthalate, polypropylene, and polyethylene were detected, as well as contaminants including copper phthalocyanine and indigo. This study provides a significant contribution to the understanding of microplastic pollution in the Amazon region, offering essential scientific support for environmental monitoring, the development of mitigation strategies in urban areas, and the conservation of regional aquatic ecosystems.

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Spatial distribution and composition of solid waste pollution along the banks of the Amazon River, Brazil

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Pollution from solid waste mainly results from improper disposal and inadequate waste management, causing environmental degradation and risks to human health. This study characterized solid waste pollution along the left bank of the Amazon River, Brazil. Eleven sampling points were established across upstream, midstream and downstream sections of the town of Itacoatiara, spacing 960 m (Fig. 1). A total of 7,350 solid waste items/km² were collected, ranging from zero to 1,800 items/km² per section, mean 111 ± 312 items/km². The results indicate higher concentration of solid waste in the central region of the left bank (Fig. 2). Statistical analysis revealed significant differences in mean concentrations among sections. The solid waste observed was predominantly plastic, mean 518 ± 626 items/km². Statistical tests showed significant differences in abundance of material types. Plastics were recorded mainly in central sections, with fragments originating primarily from bags, bottles and fibers. Observed variations in waste abundance among sections and material categories were significant. The sampling sections ranged from "dirty" to "extremely dirty" according to the General Index and the Clean Coast Index, with central areas most impacted. The Plastic Abundance Index indicated a high presence of plastics, and central sections showed the highest values for hazardous solid waste. The Environmental Status Index classified the sections as poor, indicating compromised environmental quality and impaired ecological integrity. These results support public mitigation policies, environmental education and solid waste monitoring programs in Itacoatiara and along the banks of the Amazon River, safeguarding communities.

Microplastic pollution in surface water and sediments of Lake Canaçari, Central Amazonia

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Microplastic pollution has received increasing attention from the scientific community and regulatory agencies due to its widespread distribution and potential environmental and health risks. Given the knowledge gap regarding microplastics in Amazonian lakes, this study aimed to quantify and characterize microplastics in the surface water and sediments of Lake Canaçari during the dry and flood periods, which are characteristic of the region's hydrological dynamics. Results indicate that microplastics were present in all areas and sampling periods (Fig. 1-2). The highest mean abundances were observed in the fishing area, particularly during the dry season, when the greatest variability in concentrations among areas was recorded. In total, 22,000 microplastics·m^{-3} were detected across the fishing and residential areas of the lake. Concentrations ranged from 0 to 3,000 microplastics·m^{-3}, with an overall mean of 261.90 ± 468.76 microplastics·m^{-3}. In sediment samples, microplastics were detected in all areas and sampling periods, indicating a constant input of these contaminants into the lacustrine environment. Overall, 3,166.67 microplastics·kg^{-1} dry sediment were recorded, with values ranging from 0 to 383.33 microplastics·kg^{-1} dry sediment and an overall mean of 37.70 ± 73.14 microplastics·kg^{-1} dry sediment. Samples were dominated by fibers, particularly blue ones, with sizes below 1,000 µm. Polyethylene was the main polymer identified using FTIR and Raman spectroscopy. Additionally, copper phthalocyanine and terre-verte dyes associated with microplastics were detected. These findings provide essential information to support research and management strategies addressing microplastic pollution in lacustrine environments, contributing to the understanding of its ecological impacts in the Amazon region.

Impedimetric aptasensor for the Rapid Detection of *Escherichia coli* In biological samples

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Pathogenic bacteria threaten healthcare systems and the food industry, especially because their rapid detection remains challenging. Electrochemical biosensors are emerging as a useful technology for the detection of pathogens due to their features such as low cost, rapid response time, and portability, making them an effective alternative to traditional methods. In this context, aptamers are promising tools for their inherent high selectivity toward bacterial hosts, which is of fundamental importance when detecting bacterial pathogens in complex biological samples.

In this study, we present the development of a low-cost and portable sensor based on the aptamer P12-55 for the rapid detection of Escherichia coli (E. coli). Screen-printed gold electrodes functionalized with aptamer P12-55, and electrochemical impedance spectroscopy was applied to evaluate the change of the charge transfer resistance (Rct) as a result of the interaction with E. coli ATCC 25922. The performance of aptamer-based biosensor was investigated under physiological conditions. We only observed remarkable change of the Rct in the presence of the target E. coli bacteria. This confirmed that the aptamer P12-55 sensor only targets E. coli species.

In addition, the biosensor's specificity respect to other bacterial species, including Gram-positive bacteria such as Staphylococcus aureus and the Gram-negative bacterium Pseudomonas aeruginosa was evaluated, and a non-significant impedimetric signal was observed. Notably, the biosensor successfully identified E. coli bacterial cells in a complex matrix such as urine and tap water, opening the possibility of its use in a real case scenario.

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