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INTEGRATED STRATEGIES FOR PLASTIC MANAGEMENT: MONITORING, BIOLOGICAL IMPACT, AND CIRCULAR PERSPECTIVES ROUND TABLE REPORT

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Introduction

The PLASTAMINATION Congress held on 13 February 2026 at the University of Palermo, convened a multidisciplinary panel of experts to address the escalating challenge of micro- and nanoplastic (MNP) contamination. Characterized during the session as a *silent invasion* MNP pollution represents a systemic threat that bridges environmental degradation and human pathology. This round table synthesized perspectives on the entire plastic lifecycle: from urban point sources and regional monitoring to ecotoxicological risks and advanced materials engineering. The discussion underscored that the traditional conceptual boundary between the environment and the human organism is no longer sustainable, necessitating a coordinated scientific and institutional response grounded in the *One Health* framework.

Science communication and public responsibility

The round table opened with a reflection on the role of science communication and public responsibility, moderated by Giorgia Görner Enrile, journalist for SciliaMedica.it and ilSicilia.it, who framed the discussion around the relationship between scientific knowledge, information, and society. Communicating health today means more than sharing scientific results, because communication itself carries an ethical responsibility toward society. The III PLASTAMINATION Conference 2026 and the project PLASTAMINATION Poly (Lactic Acid) plastics contamination therefore address not only the issue of plastic and MNP contamination, but also the way scientific evidence reaches the public and the effects it may generate in terms of trust, fear, or awareness. The One Health perspective reminds us that environmental, animal, and human health remain deeply interconnected, but it also highlights the responsibility involved in communicating these topics, since scientific data and research findings can easily enter public debate and sometimes become instrumentalized within environmental, social, or political narratives. Public discussion does not necessarily represent a problem, but difficulties arise when the complexity of scientific research becomes reduced to simplified messages or slogans. This dynamic becomes even more evident within the contemporary information ecosystem, where media attention often focuses on headlines rather than on scientific context, while information increasingly circulates through social networks whose visibility mechanisms depend more on algorithms than on the reliability of sources. In this environment, communication about health and environmental risks should not only inform but also encourage critical thinking, helping people recognize reliable information and distinguish between evidence, interpretation, and sensationalism. Transparency therefore plays a crucial role in scientific and institutional communication, but transparency does not mean oversimplification or reassurance at any cost, since trust grows from clarity and from the recognition of the limits that accompany scientific knowledge.

Environmental monitoring and infrastructure vulnerabilities

Effective mitigation of marine plastic pollution begins with robust environmental surveillance and standardized monitoring programmes. Dr. Salvatore Campanella and Dr. Alessandro Aglialoro, ARPA Sicilia, presented the environmental monitoring activities carried out by the regional agency within the framework of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC). This European policy instrument aims to achieve and maintain the Good Environmental Status (GES) of marine waters through coordinated monitoring systems implemented by Member States and supported in Italy by the Ministry for the Environment, ISPRA, and the National System for Environmental Protection (SNPA). Within this framework, ARPA Sicilia conducts periodic monitoring campaigns in coastal and offshore waters using standardized sampling protocols. These surveys include the collection and analysis of seawater, marine sediments, and biological matrices (biota) in order to assess environmental quality and detect the presence of anthropogenic contaminants. Monitoring activities also address the distribution of marine litter and microplastics, including the assessment of floating debris, beached litter, and microplastic particles in the water column and sediments, as required by the indicators of Descriptor 10 (Marine Litter) of the Marine Strategy. The data generated through these monitoring programmes contribute to national and European environmental reporting systems and support the scientific assessment of the eco-

logical status of the Mediterranean Sea. These datasets provide an essential basis for environmental policy, risk assessment, and the development of mitigation strategies at both national and European levels. In addition to monitoring activities, ARPA Sicilia participates in international scientific cooperation initiatives and promotes environmental education and awareness programmes, including outreach activities aimed at schools and local communities, with the objective of increasing public understanding of marine pollution and fostering sustainable environmental practices. However, the urban origin of plastic contaminants remains a critical factor in their transfer to aquatic environments. Prof. Michele Torregrossa (University of Palermo) highlighted the dual role of wastewater treatment plants (WWTPs) in the environmental dynamics of microplastic pollution. On the one hand, conventional wastewater treatment processes, including primary sedimentation, biological treatment, and secondary clarification, together with advanced technologies such as membrane bioreactors (MBRs), are capable of removing a substantial fraction of microplastics from treated effluents. Several studies report removal efficiencies frequently exceeding 90% for larger microplastic particles, although efficiency depends on particle size and plant configuration. On the other hand, WWTPs act as accumulation points for microplastics, since most of the particles retained during treatment are transferred to sewage sludge. This creates a secondary environmental concern, particularly when sludge is reused in agriculture or disposed of in landfills, potentially reintroducing microplastics into terrestrial ecosystems. The situation may be further exacerbated by extreme weather events associated with climate change. During intense rainfall, combined sewer systems may generate Combined Sewer Overflows (CSOs), temporarily bypassing wastewater treatment plants and discharging untreated wastewater directly into receiving water bodies. Under these conditions, several studies have reported that microplastic concentrations in urban runoff and CSO discharges can be up to 5 or 10 times higher than those measured in treated wastewater effluents. This increase is mainly related to the wash-off of urban surfaces, the mobilization of plastic particles accumulated within sewer networks, and the resuspension of sediments during high-flow conditions. These findings highlight the need for integrated management strategies addressing both urban wastewater infrastructure and plastic pollution mitigation, in order to reduce the transfer of microplastics from urban systems to aquatic environments.

Biological risks

From Ecotoxicology to Human Health The transition of plastics from environmental matrices to biological tissues was a central theme. Prof. Federica Scalia (UniKore) presented evidence regarding the *invisible* risks of biodegradable polymers, specifically Polylactic Acid (PLA). Utilizing the zebrafish model, her research demonstrated that PLA nanoplastics can bioaccumulate in zebrafish, especially in the gastrointestinal system, within 120 hours post-fertilization. These exposures were linked to significant gene expression alterations, specifically in cellular stress markers, suggesting that *eco-friendly* alternatives require rigorous toxicological scrutiny during embryonic development. These findings resonate with the human health perspectives shared by Prof. Stefania D'Angelo (Parthenope University of Naples). MNPs have shifted from being external contaminants to internal systemic constituents, detected in the lungs, liver, placenta, and brain. The discussion detailed how MNPs trigger oxidative stress, chronic inflammation, and the disruption of critical biological barriers. Of particular clinical concern is the presence of MNPs within atherosclerotic plaques, which is increasingly associated with a higher risk of major cardiovascular events, and their potential role in neuroinflammatory processes related to dementia.

Circular solutions and materials science

To counter these threats, the panel explored resilient technological pathways. Prof. Annamaria Visco (University of Messina), principal investigator of the European LIFE RESTART project, presented an applied model of circular economy in the field of polymeric materials, based on the valorization of agro-industrial by-products and their integration into biodegradable polymer matrices. The project, funded under the LIFE Programme of the European Union, aims to develop sustainable composite materials obtained from residual biomass derived from agricultural and agro-industrial supply chains, contributing to the reduction of fossil-based raw materials and promoting new circular production models. The research activities carried out by the University of Messina research group have led to the development of polymeric biocomposites obtained by incorporating plant residues and agro-industrial by-products into biodegradable matrices. This approach allows the valorization of organic waste streams, transforming them into high-value materials, while simultaneously reducing the environmental impact associated with conventional plastic production. A key element of the project is the establishment of the "*Fabbrica Zero*" pilot plant in Roccavaldina (Messina), a demonstration facility designed to transfer laboratory research results to an industrial scale. Within this framework, materials developed in academic laboratories are processed through technologies compatible with existing industrial transformation processes, demonstrating the technical feasibility of producing biocomposites from residual biomass. During the discussion, the economic dimension also clearly emerged as a critical factor influencing the large-scale adoption of these materials. The development and production costs of sustainable biocomposites are currently higher than those of convention-

al fossil-based plastics, particularly during the early phases of technological deployment. As a result, many companies face significant challenges in independently sustaining the transition toward more sustainable materials. It was therefore highlighted that a structural transformation of production systems requires not only scientific innovation but also targeted policy measures and economic incentives capable of supporting companies in adopting environmentally sustainable materials and processes. In this context, Prof. Andrea Pace (University of Palermo) emphasized that the development of new materials must be framed within a broader perspective integrating scientific research, industrial policies, and innovation governance. According to Pace, the transition toward more sustainable polymeric materials cannot rely solely on technological progress but requires the creation of innovation ecosystems in which universities, research centers, industries, and public institutions collaborate in a coordinated and structured manner. It emerged that strengthening technology transfer mechanisms, supporting applied research, and developing dedicated funding instruments could play a crucial role in accelerating the integration of sustainable materials into industrial systems. In this perspective, policy tools such as incentives for companies adopting low-impact materials, green public procurement strategies, and innovation programmes promoted at the European level could significantly reduce the economic barriers that still limit the widespread adoption of these technologies. Finally, Dr. Dario Scalia, Plastic Free Onlus highlighted the crucial role of civil society in addressing plastic pollution. Alongside technological solutions and industrial policies, environmental volunteering initiatives, awareness campaigns, and territorial clean-up activities represent concrete tools to reduce plastic dispersion in natural ecosystems and to promote collective responsibility in environmental protection. During the discussion, the importance of environmental education targeting younger generations was also strongly emphasized. Educational programmes in schools, awareness initiatives, and participatory activities involving students represent key instruments for fostering a culture of sustainability from an early age. It emerged that engaging children and young people in environmental education initiatives can play a fundamental role in shaping long-term behavioral change and in promoting responsible attitudes toward environmental protection.

Conclusion

The PLASTAMINATION round table concluded that the fight against plastic contamination requires an integrated, multi-scalar approach. Enhancing the filtration capacity of WWTPs is insufficient if the resulting sludge is not managed or if materials are not designed for sustainability from their inception. The detection of epigenetic impacts and the systemic accumulation of plastics in vital human organs mandate a paradigm shift: plastic is no longer merely a waste management issue but a critical determinant of global public health.