HORIZON-CL6-2025-01-ZEROPOLLUTION-04

Potential contribution of CNR-IRSA

CNR-IRSA (Water Research Institute of the National Research Council of Italy) provides the know-how in water treatment, quality, and management, with a focus on the fate of chemical and microbiological contamination in natural and engineered aquatic systems, along with innovative applications for wastewater remediation through advanced processes. The research team, composed of experienced researchers with complementary skills in environmental microbiology and microplastic detection, can provide expertise on the monitoring and definition of aquatic systems, quality status and ecology, the use of different technologies and materials for water treatment through advanced physical, chemical, microbiological, and ecotoxicological methodologies. The team has long standing knowledge on (i) the assessment of the fate and effects of contaminants, including organic and inorganic chemicals, pathogens and microbiological elements of human health concern, and macro/micro/nano-plastics; (ii) the characterization of aquatic biological communities, including, prokaryotes, protists, and eukaryotic organisms in all aquatic ecosystems; (iii) the advanced characterization and functionalization of advanced materials, including carbon-based materials to be applied in water treatment; and (iv) the design and understanding of water treatment processes, including adsorption processes and bioremediation.

Within the scope of this call, CNR-IRSA can contribute through a multidisciplinary team to the achievement of the following expected outcomes:

(i) Integrated characterization and monitoring of plastics and microplastics in the environment
CNR-IRSA is positioned to support the implementation of activities related to microplastic identification, quantification, and polymer analysis across different environmental compartments. The multidisciplinary approach integrates chemical, biological, and environmental expertise, allowing a comprehensive contribution to research, data interpretation, and the development of sustainable mitigation strategies.
CNR-IRSA is actively involved in numerous projects addressing plastic pollution, with a comprehensive approach that spans several research dimensions. These include monitoring initiatives aimed at assessing the presence of plastics in various environmental compartments and identifying their sources and environmental pathways. These projects also investigate the dynamics of microplastic transport in relation to environmental factors such as rainfall intensity, river discharge, and seasonal variations to better understand the conditions that influence their distribution and accumulation. In parallel, projects are being carried out to investigate the mechanisms of plastic degradation and the environmental variables that influence these processes. Additionally, CNR-IRSA conducts studies on the degradation products of plastics, analyzing their impact on ecosystems, including their ecotoxicological effects.
Through validated methodologies, including filtration procedures and stereomicroscopic separation, CNR-IRSA is capable of extracting plastic and microplastic particles from water, sediment, and environmental samples. Microscopy-based techniques are applied to identify structural features, including sizes, shapes, plastic type, and polymer composition, enabling a thorough classification by morphology and potential source (e.g., fragments, filaments, sheets).
Dried microplastics are quantified, weighed, and sorted to assess environmental contamination levels. To determine polymer composition, CNR-IRSA employs high-resolution analytical tools, such as Fourier Transform Infrared spectroscopy (FT-IR) in attenuated total reflection mode (ATR), and micro-FTIR, ensuring reliable material identification at the microscale. These analytical capabilities contribute to comprehensive environmental assessments, pollution monitoring, and support for regulatory and remediation strategies related to plastic pollution.

(ii) Microbial and functional profiling of plastic-associated biofilms and health risk assessment
CNR-IRSA can contribute with new insights into the microbial ecology of plastic-associated biofilms (the "plastisphere") through a combination of molecular and bioinformatic approaches. Microbial communities colonizing microplastics are characterized using next-generation sequencing platforms, including Illumina and Oxford Nanopore Technologies, targeting both 16S rRNA genes and metagenomic DNA (shotgun metagenomics). These analyses can provide a comprehensive overview of the taxonomic, genetic, and functional diversity of the plastisphere. Bioinformatic pipelines are applied to reconstruct taxonomic and functional profiles, enabling the identification of microbial taxa and functional genes, with particular attention

to those associated with pathogenicity and antibiotic resistance (AR). The presence of bacterial species of human health concern (e.g., *Vibrio* spp., *Salmonella* spp.) may be validated using targeted molecular diagnostics such as Loop-mediated Isothermal Amplification (LAMP), enabling specific and rapid detection. Quantitative assessments of antimicrobial resistance genes (ARGs), including *ampC*, *ermB*, and *sul1*, can be performed using real-time PCR and droplet digital PCR, contributing to the evaluation of microplastics as potential vectors of AR in aquatic environments. Statistical and multivariate analyses are expected to explore correlations between microplastic properties (e.g., polymer type, size, shape), microbial community structure, and environmental parameters. These analyses aim to deliver a holistic understanding of the interactions between plastic pollution and microbial dynamics, with implications for ecosystem health and potential human exposure pathways.

(iii) Strengthened institutional cooperation and support for environmental monitoring and policy

The project may benefit from the consolidated institutional partnerships of CNR-IRSA with national and regional environmental authorities, which can enhance the operational capacity and policy relevance of the research activities. CNR-IRSA maintains strengthened cooperation with regional environmental protection agencies (ARPA Lombardia, ARPA Piemonte, ARPA Lazio), which are responsible for pollution monitoring in freshwater and marine environments across Italy. These partnerships can support the integration of project outcomes into ongoing monitoring frameworks and regulatory practices. In addition, in the context of cross-border water governance, CNR-IRSA collaborates closely with the International Commission for the Protection of Italian-Swiss Waters (CIPAIS), under whose scope and guidance several research and monitoring projects are currently being implemented. Further reinforcing its international engagement, CNR-IRSA is also actively involved in projects conducted at the Joint Research Centre (JRC) of the European Commission, contributing scientific expertise to support EU environmental policies and transboundary water management. CNR-IRSA activities are further supported by strong collaborations with various environmental organizations, including Legambiente, one of the most prominent environmental NGOs in Italy. These partnerships may enhance science-society interaction, support dissemination activities, and contribute to awareness-raising efforts on plastic pollution and environmental risks.

Ongoing Research Projects

PRIN 2022 PNRR. MINOSSE: Managing plastic transport in rivers and coastal areas

PRIN 2022. BIOPLACE: Impact of degradation products of biodegradable plastics on biogeochemical cycle and freshwater environments

PRIN 2022. PET2POLY: From polyethylene therephtalate waste to bioactive polymers: an innovative bioeconomy approach

Fondazione Cariplo. PROPLA: Protein from plastics.

Fondazione Compagnia di San Paolo. Cusio2030

CIPAIS, Campagna 2022 - 2024 e 2025 - 2027. Monitoraggio della presenza di plastiche nelle acque, nella catena trofica e nei sedimenti del Lago Maggiore.

Regione LOmbardia, AQST Lago di Varese. Salvaguardia e Risanamento del Lago di Varese