COST Action CA20101 PRIORITY — WG1 Report on Impacts & Risks Analysis with Mitigation Strategies

Prepared for: WG1 — Impacts & Risks on Human Health and Environment

Source: Action Participants survey (Google Forms PDF). Responses used: 52 (anonymized).

Confidentiality: All names, email addresses, and personally identifying details were excluded. Only aggregate, anonymized results are reported.

Background & Context

As the COST Action PRIORITY (CA20101) concludes its fourth year, a final survey was distributed to Action participants (>550 members) to inform the closing report. The present document synthesizes the 'Impacts and Risk Analysis' section —structured across Human Health and Environment—together with mitigation and management proposals and the role of networks such as PRIORITY in risk assessment, communication, and policy translation. Responses were screened for relevance and confidential details were removed. The analysis focuses on qualitative signals aggregated into thematic categories.

General Information

Please specify your primary affiliation country (choose from the 53 COST countries registered in the eCOST platform for our Action)

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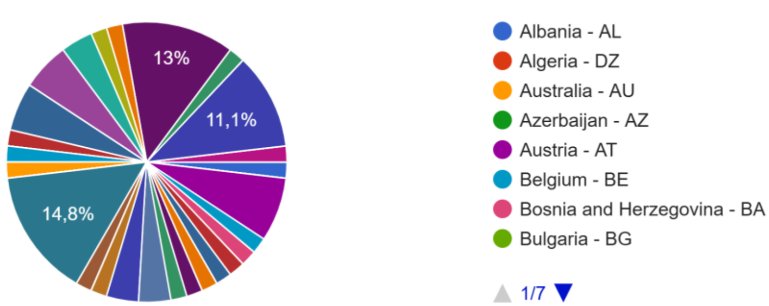

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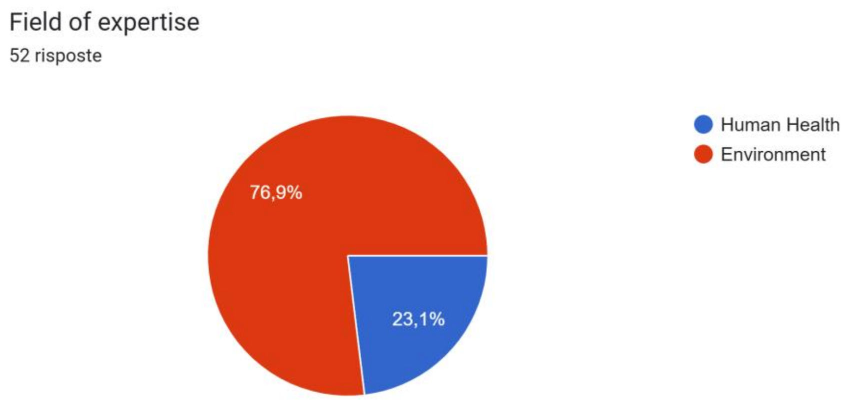


1. Human Health — Exposure Routes & Perceived Impacts

1.1 Overview and Perceived Impact

Survey participants generally agree that the **impact of micro- and nanoplastics (MNPs) on human health is a growing concern**, though the evidence base remains incomplete and sometimes contradictory. While **no definitive causal links** between MNP exposure and specific human diseases have been established, a majority of respondents emphasized that **chronic, low-level exposure** may contribute to **inflammatory, oxidative, and metabolic disorders**, potentially affecting the **gut, immune, and reproductive systems**.

Several participants highlighted inflammation as a **key early biological response** to MNP exposure, with **oxidative stress** and **gene expression alterations** as secondary mechanisms. Others cautioned against overinterpreting the current data, describing the evidence as **limited, fragmented, and not yet epidemiologically robust**.

A few responses expressed skepticism or uncertainty, noting that the overall impact remains *"mostly unknown"* or *"not finely evaluated"*, and that **large, well-designed cohort studies** are needed before defining MNPs as proven health hazards.

A minority (approx. 10%) considered the impact already **"very bad" or severe**, citing emerging data on the **presence of micro- and nanoplastics in human tissues and fluids** (blood, placenta, lung) and the **potential for sub-chronic inflammation** to exacerbate pre-existing diseases.

In summary, perceptions ranged from *"limited but plausible risk"* to *"severe and underestimated hazard"*, reflecting the broader scientific uncertainty and the need for **mechanistic and exposure-relevant research**.

1.2 Reported Health-Related Issues

Respondents identified several **health-related mechanisms and observations** linked to MNP exposure:

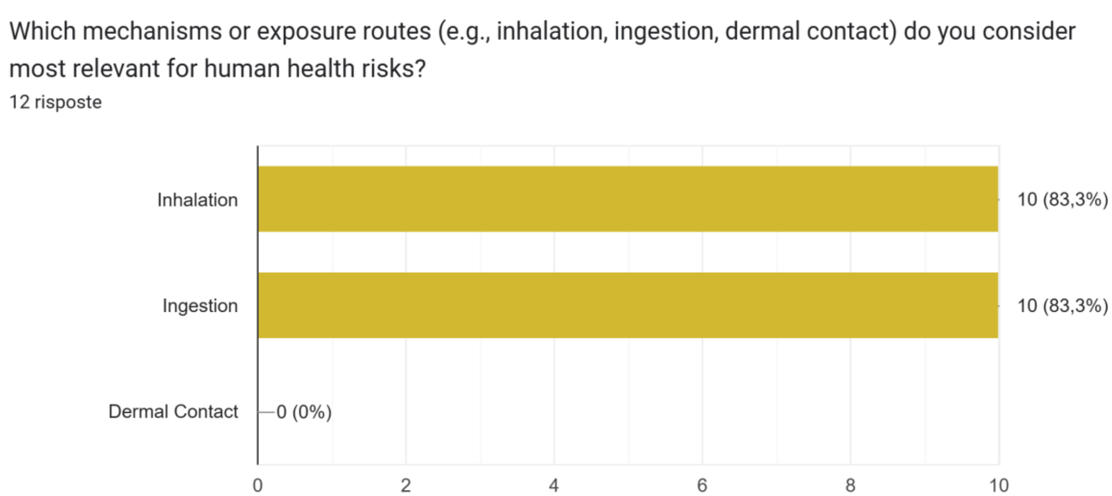
- **Inflammation** at sites of exposure (particularly respiratory and gastrointestinal tissues);
- **Oxidative stress and altered gene expression** in human cell models;
- **Potential bioaccumulation** of micro- and nanoplastics across multiple human tissues and fluids, though the **statistical significance and metrological reliability** of these studies remain debated;
- **Association with inflammation-related diseases**, including **metabolic and possibly cancer-linked pathways**.

Overall, these accounts underline MNPs as a **potential long-term health hazard**, warranting **toxicological, mechanistic, and epidemiological investigations** under harmonized quality-assured conditions.

1.3 Exposure Routes

Respondents consistently recognized **inhalation and ingestion** as the two primary exposure pathways for humans. **Dermal contact** was not considered relevant, consistent with the current scientific consensus that **respiratory and oral uptake** represent the dominant exposure routes.

This aligns with recent literature identifying **indoor air, drinking water, food, and dust inhalation** as the main entry points for MNPs into the human body.



1.4 Proposed Mitigation Measures

Participants proposed a wide range of actions to mitigate potential health risks, grouped below by theme:

Policy and prevention

- Reduce or ban **single-use plastics** and limit overall **plastic production**, especially of polymers prone to fragmentation.
- Introduce **legislative actions** and **global coordination mechanisms** targeting primary microplastics and additives of concern.
- Incentivize **eco-design** and **safer polymer formulations** that degrade into less persistent residues.

Infrastructure and monitoring

- **Upgrade wastewater treatment plants** and **improve solid waste management** to prevent environmental leakage and secondary human exposure.
- **Standardize monitoring methods** to track MNPs in **air, water, food, and biological matrices**, including human tissues.

Scientific research

- Support **toxicity and exposure studies** focusing on **polymer type, size, shape, and additive composition** as determinants of risk.
- Evaluate the safety of **biodegradable plastics**, considering their potentially faster degradation but uncertain toxicity.

Education and communication

- Promote **public education campaigns** and **civic engagement** to encourage responsible plastic use and healthy lifestyles.
- Ensure **science-based communication** to avoid alarmism while emphasizing evidence-based risk mitigation.

Capacity building

- Create **funding opportunities and collaborative programs** to empower young researchers in plastic-health research fields.

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1.5 Role of PRIORITY and Other Networks

Respondents view the COST Action PRIORITY and similar networks as **central catalysts** for bridging science, policy, and society in the field of MNPs. Key recommendations include:

- **Fostering interdisciplinary collaboration** among chemists, toxicologists, epidemiologists, and engineers to advance understanding of exposure and effects.
- **Sharing data, methods, and expertise** through open repositories and harmonized protocols.
- **Promoting biomonitoring studies** to assess real-world human exposure.
- **Advocating for regulatory standards** and harmonized analytical frameworks across Europe.
- **Supporting training schools, workshops, and fellowships** to strengthen the next generation of researchers.
- **Enhancing engagement with policymakers, NGOs, and media** to ensure translation of scientific findings into preventive action.
- **Promoting best laboratory practices** and **reference materials** to improve data reproducibility and reliability.

Overall, respondents agreed that PRIORITY's future contribution should focus on **evidence consolidation, capacity building, and communication**, fostering **cross-sectoral cooperation** to mitigate health risks associated with micro- and nanoplastics.

1.6 Conclusions

The collective responses highlight **growing scientific concern** but also **significant data gaps** in quantifying the health risks of MNPs. Evidence increasingly supports **biological plausibility** (via inflammation and oxidative stress), but the **magnitude and clinical relevance** remain uncertain. Mitigation should therefore combine **precautionary policy**, **standardized/harmonized monitoring**, and **long-term interdisciplinary research**. Networks such as **COST Action PRIORITY** play a critical role in coordinating these efforts and fostering the cross-disciplinary and societal engagement required to protect human health.

2. Environment — Impacts, Vulnerabilities & Risk Scenarios

2.1 Overview and Perceived Impact

Survey participants unanimously identified **MNPs** as **pervasive, persistent, and multifactorial pollutants** affecting **soil, water, air, and biota**. They emphasized that MNPs act as **physical stressors**, **chemical carriers**, and **ecological disruptors**, capable of altering nutrient cycles, modifying habitat structure, and threatening biodiversity across ecosystems.

Many respondents described MNPs as **cross-compartmental contaminants**, travelling through the **hydrological and atmospheric systems** and accumulating in **soils and sediments**, which can act as long-term sinks or **secondary sources** of contamination. This transboundary movement allows plastics to affect multiple environmental matrices simultaneously, leading to **cumulative and chronic ecosystem stress**.

Common impact themes emerging from the responses include:

- **Disruption of biogeochemical processes**, such as carbon cycling and sediment–water interactions;
- **Physicochemical habitat alteration**, including reduced soil quality, impaired sediment stability, and altered microbial community composition;
- **Direct effects on biota**, such as ingestion, growth inhibition, and reproductive or physiological stress;
- **Chemical vector effects**, through the release or adsorption of additives, heavy metals, and persistent organic pollutants;
- **Ecosystem-scale disturbances**, including impaired productivity, habitat fragmentation, and biodiversity loss.

Several experts noted that **environmentally relevant test materials** remain poorly characterized and that much current experimental work still relies on **synthetic or non-representative particles**, which may bias impact estimates. Others underlined that **additives and degradation products** could pose **greater long-term risks** than the particles themselves, highlighting the need for **mechanistic studies using realistic exposure concentrations**.

A few respondents also noted potential **positive feedback loops**, such as increased greenhouse gas emissions from disturbed sediments and altered soil microbial communities leading to **reduced crop yields**.

Overall, participants converged on the view that **MNPs are chronic, recalcitrant pollutants** capable of affecting both abiotic and biotic compartments, even if the **quantitative magnitude of their effects** remains difficult to assess with current methodologies.

2.2 Vulnerable and Under-Investigated Compartments and Organisms

Across responses, there was broad consensus that **soil ecosystems** are among the **most vulnerable and under-investigated** environmental compartments. Participants cited a lack of **global monitoring**, insufficient data from **non-European regions**, and analytical limitations in detecting nanoplastics within complex matrices.

Frequently mentioned vulnerable or knowledge-gap areas include:

- **Soils and sediments**, especially regarding nanoplastic–microbial interactions, soil structure alteration, and plant growth effects;
- **Atmospheric micro- and nanoplastics**, with particular reference to **indoor air** as a source of high exposure and long-range atmospheric transport;
- **Freshwater and estuarine ecosystems**, where MNPs influence sediment–water dynamics, nutrient exchange, and biofilm formation;
- **Soil microbiota, microfauna, and plant–microbe interactions**, critical to nutrient cycling and agricultural productivity;
- **Filter-feeding organisms** (e.g., bivalves, mussels, and planktonic species), which are the first entry points for trophic transfer;
- **Amphibians, reptiles, and early life stages** of aquatic organisms, often overlooked yet ecologically sensitive to small-particle exposure;
- **Coastal and deep-sea ecosystems**, where MNP accumulation and limited degradation lead to long-term contamination reservoirs.

Respondents repeatedly emphasized that **all compartments are interconnected** and that research should adopt a **systems-based approach**, considering **terrestrial–aquatic–atmospheric linkages** rather than treating ecosystems in isolation.

2.3 Observed and Discussed Risk Scenarios

Numerous participants reported **observations or theoretical discussions** of MNP-related risk mechanisms, particularly:

- **Bioaccumulation and trophic transfer**, from lower to higher trophic levels (e.g., from microorganisms and larvae to fish, amphibians, and reptiles);
- **Ecotoxicological effects**, including oxidative stress, altered enzymatic activity, and tissue-specific biomarker responses;
- **Alterations in carbon biogeochemistry**, such as changes in sedimentary enzymatic activity (up to 25%) and modified carbon storage in marine sediments;
- **Pathogen transport and antibiotic resistance**, due to the ability of plastics to host microbial biofilms;
- **Additive leaching and chemical exposure**, especially from tire wear particles and encapsulated fertilizers;
- **Differential toxicity of aged versus virgin polymers**, with aged polyethylene microplastics exhibiting greater oxidative and tissue-specific toxicity.

Some respondents noted that **true bioaccumulation** (i.e., uptake into tissues) appears **limited for microplastics** but **potentially relevant for nanoplastics**, due to their smaller size and higher bioavailability. Others highlighted the **lack of standardized analytical techniques** to detect and quantify MNPs in biological tissues, emphasizing that **risk remains largely inferred** rather than empirically confirmed.

2.4 Recommended Mitigation and Management Measures

Participants proposed a broad suite of **mitigation and management measures** to address environmental risks, organized under five main themes:

1. Source reduction and prevention

- Reduce or ban single-use plastics and **primary microplastics** (e.g., microbeads).
- Encourage **eco-design and circular economy models**, promoting safer polymers and reusable products.
- Implement **producer responsibility and product labeling** to trace polymer sources and additives.

2. Waste management and treatment

- **Upgrade wastewater treatment plants (WWTPs)** with tertiary filtration and advanced oxidation or adsorptive technologies.
- Control **runoff and sludge application** in agriculture to minimize secondary emissions.
- Improve **plastic recycling and upcycling** processes and limit global waste export.

3. Monitoring and research

- Develop **standardized protocols** for sampling and quantification in soil, water, air, and biota.
- Conduct **long-term ecological and biomonitoring** in vulnerable ecosystems.
- Investigate **biodegradable alternatives** under realistic environmental conditions to evaluate true degradability and toxicity.

4. Remediation and restoration

- Target **hotspots** (e.g., coastal sediments, urban rivers, agricultural soils) for cleanup and remediation.
- Explore **microbial or plant-based degradation** and **nature-based solutions** for contaminated habitats.

5. Policy, education, and cooperation

- Strengthen **regulatory frameworks** and harmonize definitions of degradability and bioplastic safety.
- Support **public education campaigns** and community engagement for waste prevention.

- Provide **technical assistance to low-income regions** for sewage and waste management infrastructure.

Several respondents emphasized that **environmental mitigation must be multi-level**, combining **local actions** (e.g., WWTP upgrades) with **global agreements** (e.g., extended producer responsibility and import/export restrictions). The importance of **educational initiatives and international cooperation** was also strongly highlighted.

2.5 Role of PRIORITY and Other Networks

Respondents underlined the **strategic importance of COST Action PRIORITY** and similar networks in advancing environmental risk assessment and mitigation strategies for MNPs. They identified several key contributions:

- **Harmonization of methodologies** for sampling, identification, and quantification across environmental matrices;
- **Coordination of interlaboratory tests** and development of **reference materials** to ensure data comparability;
- **Promotion of interdisciplinary collaboration** linking chemists, ecologists, toxicologists, and policymakers;
- **Capacity building through training schools, STSMs, and joint monitoring campaigns**;
- **Creation of open databases and data-sharing platforms** to facilitate cumulative evidence;
- **Bridging science and policy**, providing expert advice and scientific input to European and national decision-makers;
- **Support for communication, outreach, and education** to raise awareness of MNP pollution and foster stakeholder engagement.

Respondents also emphasized the need for **enhanced coordination with other networks** (e.g., UNEP, Horizon Europe partnerships, and national research programs) to **avoid fragmentation and duplication** of efforts. Many noted that PRIORITY has already demonstrated a strong **community-building and standardization role**, and should continue serving as a **reference forum for risk assessment, harmonized testing, and policy translation**.

2.6 Conclusions

The collective survey results reveal a shared perception that **micro- and nanoplastics represent a long-term and systemic environmental threat**, characterized by persistence, mobility, and complex interactions with other pollutants.
The most vulnerable and least investigated compartments remain **soils, sediments, and atmospheric systems**, while **aquatic organisms, microorganisms, and early life stages** are recognized as sensitive biological receptors.

Risk scenarios such as **trophic transfer, bioaccumulation, and ecotoxicological effects** are increasingly reported, though the strength of evidence varies depending on polymer type and analytical precision. Mitigation requires **integrated strategies** addressing the full plastic life cycle—from **production and design** to **waste management, monitoring, and restoration**—supported by robust **scientific evidence and harmonized methodologies**.

Networks like **COST Action PRIORITY** play a critical role in coordinating these actions, **fostering interdisciplinary collaboration**, and **ensuring that science-based knowledge informs effective environmental protection policies** at both European and global levels.