POLICY BRIEFING — INTEGRATED EDITION

MICROPLASTICS AND PUBLIC HEALTH

Acknowledged Risks and EU Policy Action

in collaboration with

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1. Executive Summary

Micro- and nanoplastics (MNPs) represent an escalating public health and environmental crisis, with a growing body of peer-reviewed evidence demonstrating their presence in human blood, breast milk, lungs, brain tissue, placenta, and even in children's urine. These particles, once released into the environment, seem virtually impossible to remove and act as vectors for toxic substances, including endocrine disruptors, heavy metals, persistent organic pollutants (POPs), and antibiotic resistance genes. Exposure occurs via ingestion, inhalation, and dermal contact, with documented effects ranging from inflammation and oxidative stress to neurotoxicity, reproductive toxicity, developmental disorders, and carcinogenicity. Especially vulnerable populations — including children, pregnant women, and frontline communities — face disproportionate health risks, while environmental accumulation threatens ecosystems and biodiversity.

The 2024–2029 EU political cycle offers a historic window to implement systemic, science-based, and enforceable measures to mitigate these risks. This Policy Brief provides a comprehensive overview of the latest toxicological research and identifies strategic actions for policymakers to accelerate the phase-out of hazardous polymers, strengthen producer responsibility, and enhance health protection under key EU frameworks. It underscores the urgent need to embed microplastic prevention within the forthcoming Circular Economy Act, the Action Plan for the Chemicals Industry, the EU Bioeconomy Strategy, and the European Water Resilience Strategy. While recent legislative steps — such as the REACH restriction on intentionally added microplastics and the proposed regulation on pellet loss — are commendable, major regulatory gaps remain in addressing secondary microplastic formation, harmonised monitoring, and substitution incentives for safer materials.

Europe must lead by example: the EU has the mandate and the moral responsibility to champion legally binding international provisions on microplastic control, product redesign, and health monitoring. Coordinated action across Member States, robust investment in research and innovation, and the adoption of common standards for detection, risk assessment, and remediation will be critical to prevent irreversible damage to public health and the environment. The time to act is now — and the EU must be bold, ambitious, and uncompromising in its commitment to protect current and future generations from the pervasive threat of microplastics.

2. Scientists Speak Out on Microplastics and Health

> **Professor Patricia Hunt:** *"I've been locked into plasticising chemicals (like bisphenols and phthalates — chemicals that are endocrine disrupting chemicals) for over 20 years now, and everything we've done in the laboratory with these chemicals has convinced me that these chemicals not only can affect our fertility and our general health — they already are. We also know that some of the effects of these chemicals are transgenerational. That means they can affect subsequent generations even though those generations aren't themselves exposed."*

School of Molecular Biosciences, Washington State University — Plastic Health Summit 2021, 18 November 2021.

> **Professor Dr. Lukas Kenner:** *"We know that microplastic particles can enter the embryo through the placental barrier. [...] The unborn child is the one to take the biggest load of those plastic particles. I'm afraid of the fact that plastic particles could lead to early onset cancer and that the accumulation of plastic in the world and in our ecosystems can lead to more and more cancer formation in earlier years of peoples' lives. That would be basically a disaster."*

Cancer researcher and deputy director, Clinical Institute of Pathology, Medical University of Vienna — 24 April 2024.

> **Professor Dr. Thais Mauad:** *"There has been a lot of research showing that microplastics are present in our body — in each organ researchers have looked at, they found microplastics. We were the first to demonstrate that microplastics can reach the brain. [...] I confess that I became a little bit worried about how easy it is for particles to enter our brains. The brain is supposed to be our most protected organ. [...] The particles we found in the brain were mostly polypropylene, polyester, polyethylene — plastics widely produced and present in packaging, clothes, and furniture. This is very disturbing. I am afraid of plastics because of this widespread contamination. The fact that the microplastics affect DNA structure causing DNA damage has several consequences for us."*

Associate Professor, University of São Paulo — 29 November 2024.

> **Professor Dr. Shanna Swan:** *"I believe we are in crisis. I believe that the plastics in our lives are threatening our survival as a species and the survival of all planetary life. There cannot be a bigger threat. [...] Sperm count has declined 1% per year. Since 2000, the rate has increased to about 2.6% per year. Other species exposed to the same chemicals are declining too — and they are not choosing to delay childbearing. [...] My message to the petrochemical industry is you have no right to be poisoning people in multiple ways. The health effects of these chemicals on people are criminal. They did not request this exposure, they did not sign up for this exposure, and you are threatening their health — and perhaps the survival of planetary species."*

Icahn School of Medicine at Mount Sinai — 13 August 2025.

> **Professor Barbro Melgert:** *"This report (on NMP Exposure by Heather Leslie) makes a valuable contribution by systematically mapping the enormous range of everyday sources through which humans are exposed to micro- and nanoplastics. The effort to quantify exposures across product categories is exactly what the field needs to move forward. As a lung researcher, I particularly welcome the attention to inhalation as an exposure route, which remains underappreciated by the public despite evidence that it is at least as important as exposure through food and drink. This report makes clear that exposure is unavoidable and comes from all directions, and that this knowledge is essential for driving both individual choices and systemic change."*

Professor of Respiratory Immunology, University of Groningen. [Added from the companion Report — not present in the original Briefing.]

3. Recommendations for EU Policymakers

- A substantial review of the Waste Framework Directive should be a priority during this European mandate and be part of the announced Circular Economy Act. Particularly, the Act should include a review of the Environmental Producer Responsibility (EPR) schemes to make producers responsible for the whole life cycle of the product, not only the end-of-life — including the release of microplastics during use and degradation phases. EPR schemes need to actively finance waste prevention, reuse, repair, and substitution of polymer-based materials, through dedicated repair and reuse funds and infrastructure, targeted support for microplastic-free design, and aligned policy measures.
- The European Chemicals Industry Action Plan should include as urgent priority fiscal incentives and tax measures to boost demand for clean chemicals and to accelerate the substitution of hazardous and persistent polymers. The upcoming EU Innovation and Substitution Hubs, as well as Horizon Europe, should make available increased funds to accelerate the development of safer, sustainable, microplastic-free chemical substitutes.
- The workplan on textiles/apparel to be adopted by 2027 under the Ecodesign for Sustainable Products Regulation (ESPR) should include concrete and binding measures to mitigate microplastic shedding throughout the textile lifecycle — from fibre production to washing and disposal —

including standards for microfibre release, durability criteria, mandatory filtration technologies, and design-for-recyclability protocols.

- The flagship actions of the EU Water Resilience Strategy [see Editorial Note, p. below, on the precise instrument under revision] should urgently address microplastics pollution of water bodies, treating it as a major health and environmental risk, embedding urgent and enforceable targets across freshwater and marine policies.

Specifically, when discussing the above initiatives or other relevant proposals, these actions should be proposed and supported:

- Accelerating bans on high-risk microplastic sources.
- Removing market barriers for alternative materials and systems, including bio-based and biodegradable materials (e.g. packaging from agri-waste or natural fibres), through harmonised standards and support under the Bioeconomy Strategy.
- Avoiding regressive waste management costs on EU citizens by shifting towards producer-responsibility-based funding under the WFD, rather than general plastic taxes on consumers (e.g. rethink the implementation of the Single Use Plastics Directive in this light).
- Strengthening research funding under the post-2027 Multiannual Financial Framework, with a specific call under Horizon successor programmes for cross-disciplinary health-environment microplastics research.
- Ensuring strong EU leadership in the Global Plastic Treaty, with a mandate to pursue legally binding provisions on microplastic production, release, and monitoring.
- Improving public awareness and education campaigns on health and environmental risks of microplastics, especially for vulnerable groups.
- In parallel, the EU should significantly scale up investment in the development, deployment and market uptake of alternatives to conventional plastics, in order to reduce structural dependence on polymer-based materials, enabling safe, affordable and high-performing alternatives to move from niche applications to widespread use across key sectors.

4. EU Legislative Landscape

The European Union has progressively built a regulatory architecture to address the growing problem of microplastics, integrating measures into broader environmental, health, and circular economy frameworks. Central to this landscape are the Circular Economy Action Plan and the Zero Pollution Action Plan: the Commission's aim is to cut emissions of microplastics by at least 30% and marine plastic litter by 50% by 2030, framing the longer-term goal of achieving pollution levels "no longer harmful" by 2050. Key legislative shifts also include updates to the Urban Wastewater Treatment Directive and the Drinking Water Directive to introduce monitoring and mitigation of microplastics in water sources.

4.1 Adopted Laws and Their Implementation Status

Marine Strategy Framework Directive (MSFD). Adopted in 2008, the MSFD is the EU's main marine protection law, mandating coordinated national strategies to achieve "Good Environmental Status" (GES). Among its eleven environmental descriptors, Descriptor 10 (D10) addresses marine litter, including microplastics. The Directive, reinforced by Commission Decision (EU) 2017/848, sets clear monitoring requirements for microplastics (D10C2), alongside macroplastics and their impact on marine life.

Fertilising Products Regulation (FPR). In force since 16 July 2022, the FPR limits impurities in fertilisers, capping macroscopic plastics, glass, and metals at 3 g/kg dry matter (with individual plastics limited to 5 g/kg); this threshold tightens to 2.5 g/kg by July 2026, to be re-assessed by 16 July 2029 in light of progress on separate bio-waste collection. Technical additives such as anti-caking agents must meet biodegradability criteria by 2026, though Controlled Release Fertilisers (CRFs) — where polymer coatings enable targeted nutrient delivery — remain exempt, leaving gaps in addressing polymer leakage. Manufacturers must implement rigorous quality checks and staff training to identify hazardous materials.

REACH restriction on intentionally added microplastics. Adopted on 25 September 2023 (Regulation 2023/2055), this restriction bans intentionally added synthetic polymer microparticles (SPM) in products, including cosmetics, following an ECHA conclusion that such releases pose an inadequately controlled risk. To qualify as SPM, particles must be solid, non-degradable, non-soluble, carbon-containing polymers present at ≥1% by weight or forming a continuous coating; liquid, natural, degradable or soluble polymers are excluded. The ban is expected to prevent 500,000 tons of microplastic emissions over two decades. Compliance is staggered: rinse-off cosmetics by 2027, other consumer goods with intermediate deadlines, and makeup/nail products by 2035 (with warning labels required from 2031).

Single-Use Plastics Directive (SUPD). The SUPD bans or restricts the ten single-use items — including cotton buds, cutlery, plates, straws, stirrers, balloon sticks, food and beverage containers, cigarette butts, and wet wipes — that, together with abandoned fishing gear, account for 70% of marine litter. Complementary measures include design requirements (tethered bottle caps) and recycling targets (90% for bottles by 2029). The Commission will evaluate the SUPD's implementation across Member States by 3 July 2027.

Microplastics Restriction Regulation (EU 2023/2055). Effective from 17 October 2023, the Regulation establishes staggered phase-outs across product categories: rinse-off cosmetics without microbeads from October 2027, detergents from October 2028, agricultural products from October 2029, synthetic sports surfaces from October 2031, and certain makeup products from October 2035 — a phased approach designed to balance industry adaptation with environmental protection.

Packaging and Packaging Waste Regulation (PPWR). Entered into force in February 2025 and applicable from 12 August 2026, the PPWR tackles packaging waste, which accounts for roughly 40% of plastic used in the EU. Most packaging must be effectively recyclable by 2030, with recycled content requirements (currently capped at a maximum of 35% for plastic packaging) and a phase-out of unnecessary single-use packaging. Extended producer responsibility shifts the cost of non-compliant packaging onto producers. [Added from the companion Report — the PPWR was not covered in the original Briefing.]

4.2 Pipeline Laws & Proposals

Drinking Water Directive (2020/2184). Adopted in December 2020 in response to the "Right2Water" European Citizens' Initiative, and transposed by Member States by January 2023, the Directive mandates harmonised methods to monitor microplastics in tap water. On 16 May 2024 the Commission notified a Delegated Decision establishing a harmonised methodology for measuring microplastics in water intended for human consumption, with a view to including microplastics on the Directive's official "watch list" (Article 13). Under Article 19, the Commission must report to Parliament and Council by 12 January 2029 on the potential health risks of microplastics and other emerging contaminants in drinking water sources.

Pellet Loss Regulation. Proposed on 16 October 2023, the Regulation targets plastic pellet losses — estimated at 52,000–184,000 tonnes annually — through mandatory loss-prevention measures across the supply chain, combining standardised loss measurement with mandatory prevention requirements and lighter rules for micro and small businesses. The measure targets a 60–83% reduction in pellet losses, with estimated annual compliance costs of €376–491 million to businesses, offset by savings in clean-up costs and benefits to tourism and fisheries.

The Global Plastic Treaty. Under negotiation among 175 countries since the March 2022 UN Environment Assembly, this treaty aims to establish an internationally legally binding instrument on plastic pollution, including in the marine environment. The EU's position is that intentionally added microplastics should be banned outright, given their role as vectors for toxic pollutants and their impact on marine life, human health, and biodiversity.

4.3 Gaps in Current Legislation

Despite this progress, significant gaps remain. Detection methods for particles under 300 microns are inconsistent, hampering monitoring and threshold-setting under the MSFD; contamination risk and the lack of standardised protocols compound the difficulty of measuring particles below this size, while monitoring of microplastics in sediments and beaches — long-term sinks for pollution — remains limited, and spatial/temporal heterogeneity complicates trend analysis (Galgani et al., 2024).

The FPR's exemption for Controlled Release Fertilisers, and its reliance on industry self-enforcement, create risks of uneven compliance; its focus on macroscopic plastics (≥2 mm) also overlooks smaller particles that may still pose ecological risks. The REACH ban carries long transition periods (until 2035 for some cosmetics) and exemptions for soluble or biodegradable polymers. The SUPD, while effective on macroplastics, does not explicitly address fragmentation into secondary microplastics. The Microplastics Restriction Regulation excludes liquid and natural polymers, which may still contribute to pollution, and its phased timelines — while pragmatic for industry adaptation — prolong environmental exposure.

The Packaging and Packaging Waste Regulation, while setting a useful precedent, leaves mechanical recycling as a continuing source of microplastic waste, and its minimum recycled-content requirement (capped at 35% for plastic packaging) still leaves a large majority of plastic packaging made from virgin plastic — underscoring the need for the PPWR to be used as a lever for a deeper transition away from plastic in packaging.

Enforcement across Member States is uneven, and data collection lacks harmonisation, undermining policy coherence. Overall, the EU legislative landscape demonstrates clear ambition and progress but suffers from fragmentation, delayed timelines, and loopholes. Stronger harmonisation, shorter transition periods, and explicit provisions for secondary microplastics are needed. A critical next step will be to operationalise monitoring, ensure robust enforcement, and integrate microplastic controls into the broader Circular Economy and Zero Pollution objectives.

5. EU Commission's Political Guidelines 2024–2029

The European Commission's strategic orientation for 2024–2029 embeds microplastic reduction within a broader set of environmental, economic, and health objectives, even if not addressed as a standalone priority. Microplastics are considered part of the Commission's Green Deal, Circular Economy, and "Quality of Life" agenda, linking pollution prevention to human health, ecosystem resilience, and competitiveness. The guidelines provide a political mandate to translate scientific evidence into systemic action — notably through four flagship frameworks: the Circular Economy Act, the Action Plan for the Chemicals Industry, the European Water Resilience Strategy, and the Bioeconomy Strategy.

5.1 Key Priorities

Circular Economy Act. Expected in 2026, this cornerstone initiative aims to reduce waste, promote resource efficiency, and redesign products for durability, recyclability, and safe material use. For microplastics, it creates a legislative opening to address both primary and secondary emissions at the design stage, with anticipated measures including mandatory waste sorting, stronger eco-design criteria, and requirements for recycled content — likely aligning with Extended Producer Responsibility schemes to ensure polluters finance microplastic-free alternatives.

Action Plan for the Chemicals Industry. This complements the Circular Economy Act by targeting innovation and resilience in a sector facing global competition and green-transition pressures. A Critical Chemical Alliance, established with Member States and stakeholders, will identify critical production sites needing policy support, tackle supply-chain dependencies, and align investment priorities — including through Important Projects of Common European Interest (IPCEIs) — to boost research and manufacturing capacity for clean, microplastic-free materials.

European Water Resilience Strategy. This directly links microplastics with PFAS and other pollutants, recognising their role in degrading water quality and threatening health. Its flagship actions are designed to restore natural water cycles by limiting pollutants such as microplastics at source, guarantee universal access to clean and affordable drinking water, and ensure robust monitoring across the supply chain, in integration with revisions to the Marine Strategy Framework Directive and the Drinking Water Directive. [See Editorial Note below regarding the precise naming of the water-related instrument under revision.]

Bioeconomy Strategy. By promoting bio-based, biodegradable, and non-toxic alternatives to fossil-based plastics, the Bioeconomy Strategy supports the phase-out of persistent plastics across packaging, textiles, and agriculture, aligning with rural development, biotechnology innovation, and climate-neutrality goals. Stakeholder consultations and targeted workshops are shaping how the strategy can deliver microplastic-free value chains while supporting rural economies and global leadership in bio-based materials.

5.2 Funding & Research Initiatives

Understanding and addressing the health impacts of microplastic pollution requires a strong and coordinated research agenda across the EU. Through Horizon Europe and complementary Member State frameworks, the EU is investing in scientific initiatives that explore microplastic exposure pathways, toxicological effects, and ecosystem-level impacts, while strengthening data harmonisation and cross-border cooperation. [This section is substantially expanded from the companion Report; the original Briefing referenced Horizon Europe funding only in general terms.]

Horizon Europe Projects on Microplastics & Health. Notable ongoing initiatives include PlastHealth, which investigates the transfer and effects of microplastic exposure at ecosystem level using mesocosm experiments on model species (mussels, fish, crustaceans), incorporating biochemical, histopathological, and microbiome analyses to identify biomarkers of toxicity and ecosystem disturbance. Horizon calls under the 2025 "Towards comprehensive aquatic litter pollution assessment" topic focus on bridging data gaps across riverine, freshwater, coastal, and marine compartments, standardising analytical protocols, improving autonomous sampling, and integrating data into FAIR-enabled platforms such as EMODnet and the European Data Twin of the Ocean. These projects are supported by increasing calls for citizen science and open, participatory data infrastructures, consistent with the EU's broader ambitions for a European Data Union.

Member State Collaboration Framework. This framework is envisioned to align national research infrastructures — environmental monitoring networks, health surveillance systems, and R&D funding streams — to enable cross-border pilot studies, data sharing, reference material standardisation, and interoperability of analytical methodologies across national laboratories. Projected co-financing is substantial: the Clean Oceans Initiative, though not an EU-budgetary instrument, has already mobilised €4 billion for macro- and microplastics projects in the Global South, and development banks have set a joint target of €3 billion for 2026–2030 to tackle ocean plastic pollution.

5.3 Monitoring & Reporting Obligations

Monitoring and reporting obligations underpin the entire guidelines package. By 2029, the Commission will operationalise EU-wide harmonised data collection, integrating microplastics into water, wastewater, and bathing directives. This addresses current fragmentation: monitoring standards vary substantially between Member States and ecosystems under the MSFD, and freshwater/lake data remain especially patchy. The Commission is backing standardisation under the Zero Pollution Monitoring and Outlook Framework, including new watchlists under the Water Framework and Bathing Water Directives that will list microplastics as a priority pollutant alongside PFAS and personal-care micropollutants.

- Regular monitoring of microplastics in drinking water, supported by provisional revisions to the Drinking Water Directive requiring national authorities to set detection thresholds, reporting triggers, and remediation planning.
- Enhanced wastewater treatment reporting: by 2035, communities over 1,000 inhabitants must remove organic matter (expanding to nitrogen/phosphorus removal by 2045), with new steps to detect and quantify microplastics and micropollutants during treatment. These rules are tied to Extended Producer Responsibility schemes requiring cosmetic and pharmaceutical companies to cover approximately 80% of upgraded treatment costs.
- Performance indicators and digital tracking, including interoperability mandates for environmental databases tied to EMODnet, EU Open Data principles, and the EU Data Portal, enabling harmonised reporting cycles and cross-Member State comparisons.

These enhanced obligations aim to reduce existing knowledge gaps, facilitate enforcement under evolving plastic and chemical regulations, and substantially support risk-assessment capacity across European public health agencies, empowering researchers, NGOs, and policymakers to evaluate progress toward microplastics reduction goals.

Overall, the 2024–2029 political guidelines offer a coherent framework where microplastic prevention is indirectly but strongly embedded. By aligning industrial policy, water resilience, and bioeconomy development with harmonised monitoring, the Commission is setting the stage for legally enforceable and innovation-driven action. The challenge for policymakers will be to ensure that these guidelines translate into binding standards, accelerated timelines, and adequate funding so that microplastic pollution is reduced at its source rather than merely managed downstream.

6. Scientific State of the Art

Scientific evidence has rapidly advanced in recent years, transforming microplastics from a perceived nuisance into a recognised global health and environmental threat.

6.1 Definitions, Sources and Food Chain Accumulation

Microplastics are defined as synthetic solid particles or polymeric matrices, regular or irregular in shape, sized 1 µm–5 mm, insoluble in water (Frias & Nash, 2019); nanoplastics range 1–1000 nm and exhibit colloidal behaviour, forming through environmental degradation of larger plastics (UV light, hydrolysis, mechanical forces) or industrial processes (Ter Halle et al., 2016). Sources are both primary — intentionally manufactured for exfoliating cosmetics, industrial cleaners, abrasive materials, and pellets/nurdles used as raw material (Song et al., 2024) — and secondary, resulting from the fragmentation of larger plastic debris (bottles, bags, fishing nets) under UV radiation, mechanical forces, wave action, and wear (Song et al., 2024).

Food-chain accumulation. Micro- and nanoplastics are absorbed by terrestrial plants, affecting growth and biomass; high concentrations have been found in apples and carrots, contributing to accumulation in human tissues (Oliveri et al., 2020; Leslie et al., 2022). In aquatic systems, trophic transfer occurs through food webs — zooplankton ingest MNPs and pass them to fish and molluscs consumed by humans, increasing exposure risk for top predators, including humans (Cole et al., 2013). [This subsection is new material from the companion Report, not present in the original Briefing.] Plastics pose a growing and under-recognised threat to human and planetary health at every stage of their lifecycle, from raw material extraction to disposal, with associated global health and economic costs projected to worsen as plastic production nearly triples by 2060 without urgent action (Landrigan et al., 2025).

Exposure occurs via three main pathways. Ingestion is the dominant pathway: seafood, drinking water, bottled beverages, condiments, honey, chicken, and vegetables are major vectors (Sangkham et al., 2022), and heating food or beverages in plastic containers accelerates particle release, a particular risk for infants consuming formula from plastic bottles (Chen et al., 2023; Hu et al., 2023; Shruti et al., 2024). Inhalation is significant especially in urban and industrialised environments, where airborne microplastics penetrate deep into the lungs (particles below 2.5 µm can reach the alveolar region, Kelly & Fussell, 2012; Falakdin et al., 2024); airborne particles have also been detected in remote alpine and polar regions, underlining their global dispersion (Kau et al., 2024). Dermal exposure, though less studied, occurs via cosmetics, personal care products, topical medications, and masks, with evidence that nanoplastics can penetrate skin cells (Gamage & Mahagamage, 2024; Martin et al., 2024).

6.2 Health Impacts

Laboratory and animal studies show effects including intestinal disruption, cardiovascular damage, neurotoxicity, and reproductive harm. At the cellular level, microplastics induce inflammation, oxidative stress, mitochondrial dysfunction, apoptosis, and DNA damage (Li et al., 2021; Jin et al., 2022; Wang et al., 2023; Zhou et al., 2023; Schirinzi et al., 2017; Poma et al., 2019; Wu et al., 2020).

Carcinogenic potential. Micro- and nanoplastics may contribute to cancer development through several mechanisms identified in preclinical studies: inducing tumour-promoting inflammation via increased inflammatory cytokine production (Forte et al., 2016; Xu et al., 2022; Shi et al., 2024), enabling anchorage-independent cell growth (Barguilla et al., 2022), suppressing immune surveillance through decreased NK-cell activity and macrophage polarisation (Hu et al., 2021), and showing genotoxic potential in human blood cells (Gopinath et al., 2019; Ballesteros et al., 2020). MNPs dysregulate cell proliferation and induce epithelial-mesenchymal transition that enhances cancer-cell invasiveness (Halimu et al., 2022;

Traversa et al., 2024). Elevated concentrations have been observed in lung (Pauly et al., 1998), colorectal (Cetin et al., 2023), and prostate cancer tissues (Deng et al., 2024), though whether this reflects bioaccumulation or a causal relationship requires further investigation; plastic particles have also been found to increase cell migration and metastatic spread (Brynzak-Schreiber et al., 2024).

Developmental teratogenicity. Polystyrene nanoplastics show significant teratogenic effects when parents are exposed during reproductive periods: co-parental exposure has been linked to skeletal and visceral malformations, reduced fetal growth, impaired neonatal reflexes, and learning deficits in adult offspring, alongside changed neurotransmitter levels, reduced antioxidant enzyme activity, and structural brain damage (Kaur et al., 2025). [New material from the companion Report.]

Neurological and brain effects. MNPs cross the blood–brain barrier and accumulate in the brain, where they may induce neuroinflammation, apoptosis, and neuronal damage, potentially contributing to neurodegenerative diseases such as Alzheimer's and Parkinson's (Kopatz et al., 2023; Yin et al., 2022). The first research identifying MNPs in the brain found a concentration in the olfactory bulb, suggesting inhalation and the nasal pathway as a dominant access route (Amato-Lourenço et al., 2024). MNPs interfere with mitochondrial function, synaptic transmission, and cellular metabolism, and MNP-induced intestinal inflammation may adversely affect brain function through the gut–brain axis (Yang et al., 2023); the smallest, chemically modified particles exhibit the highest neurotoxicity (Liu et al., 2022).

Reproductive health. Human epidemiological data point to a documented, accelerating decline in sperm count — about 1% per year historically, rising to roughly 2.6% per year since 2000 — alongside comparable declines in other species exposed to the same chemicals, independent of any delay in reproduction (Swan, cited above).

Children's health. Children are particularly vulnerable due to their ongoing physiological development and higher intake relative to body weight (Chia et al., 2025). MPs have been detected in blood, breast milk, placenta, and brain tissue, and have been associated with preterm birth (Chia et al., 2025), endocrine disruption (Ullah et al., 2023), neurological and cardiovascular effects (Prüst et al., 2020), and immune system alterations (Morrison et al., 2022). In children and adolescents, MPs may cause mitochondrial damage, liver injury, renal oxidative stress, and respiratory inflammation, potentially contributing to asthma and bronchitis (Chia et al., 2025). A study of 1,000 children aged 6–9 (Dong et al., 2025) found a significant association between urinary microplastics — particularly polyamide, polypropylene, and PVC — and behavioural problems, including emotional symptoms, conduct problems, hyperactivity, peer-relationship difficulties, and reduced prosocial behaviour, suggesting a potential neurobehavioural risk from early-life exposure. [New subsection from the companion Report, not present in the original Briefing.]

Chemical additive leaching. Beyond their physical presence, microplastics pose additional risks through the leaching of embedded chemical additives. Recent comprehensive reviews show that microplastics can release flame retardants, plasticizers, and antioxidants — many with endocrine-disrupting, neurotoxic, and reproductive effects — particularly after ingestion, where digestive enzymes, acids, fats, and oils accelerate degradation and chemical migration, underscoring microplastics as an active chemical exposure pathway rather than inert particles.

6.3 Synergistic Interactions with Other Pollutants, Viruses and Bacteria

Microplastics do not act alone but also as vectors of other pollutants, absorbing heavy metals, persistent organic pollutants (POPs), pesticides, phthalates, bisphenols, and PFAS, and creating complex toxic cocktails.

Additives and heavy metals. Brominated flame retardants, UV stabilisers, dioxins, phthalates, alkylphenols, bisphenol A, and PFAS are all documented plastic-associated chemicals with endocrine-disrupting, neurotoxic, or carcinogenic effects (Weis & Alava, 2023; Wiesinger et al., 2021). MNPs act as efficient vectors for heavy metals through electrostatic interactions and high surface area, with aged particles showing increased adsorption capacity for mercury, lead, cadmium, and titanium (Kumar et al., 2021; Patterson et al., 2020); co-exposure studies show synergistic effects where MNPs combined with cadmium significantly enhance oxidative stress, neurotoxicity, and metal bioaccumulation compared to single exposures (Tuncelli et al., 2024; Tourinho et al., 2023).

Persistent organic pollutants and pesticides. Microplastics adsorb POPs such as DDT and PCBs at concentrations up to six times higher than in surrounding water (Tumwesigye et al., 2023; Liu et al., 2021); MPs carrying PCBs have been linked to a higher incidence of cancer and developmental abnormalities in zebrafish larvae (Hu et al., 2024). Microplastics also significantly affect pesticide behaviour, both reducing bioavailability through adsorption and increasing persistence, complicating the overall assessment of their combined toxicity (Tang, 2025).

Antibiotic resistance and bacteria. Microplastics co-occur with antibiotics and antibiotic resistance genes (ARGs) in subsurface environments, acting as carriers that facilitate their transport and persistence, and promoting enrichment of tolerant bacterial genera such as Acinetobacter and Pseudomonas (Yashir et al., 2025). Nanoplastics — particularly carboxyl-functionalised polystyrene particles — have been shown to significantly promote ARG spread by inducing oxidative stress through hydrogen peroxide overproduction, which increases bacterial membrane permeability, activates the SOS response, and facilitates uptake of exogenous DNA (Li et al., 2025).

Viruses. Polystyrene nanoplastics have been shown to exacerbate viral infections in fish by impairing host-cell function and immune responses: in a study on largemouth bass fin cells infected with Largemouth bass ranavirus, nanoplastics significantly promoted viral replication, intensified virus-induced inflammatory responses, and suppressed antiviral defences by downregulating the cGAS–STING signalling pathway (Zhi et al., 2024), suggesting nanoplastics may increase host susceptibility to viral infection.

6.4 Detection and Measurement Challenges

The characterisation of micro- and nanoplastics involves complex analytical workflows with significant limitations. Pretreatment processes can cause loss or alteration of target materials, while physical identification through microscopy suffers from observer subjectivity and limited resolution for nanoplastics. Chemical identification using vibrational spectroscopy (FTIR, Raman) is limited by particle size and water interference, whereas mass spectrometry provides sensitive analysis but requires sample destruction. Nanoplastics present unique challenges due to increased Brownian motion, sub-wavelength size, and enhanced surface reactivity. Innovations including self-propelled micro/nanorobots, optical tweezers with Raman detection, and machine learning-enhanced hyperspectral imaging offer promising pathways for real-time, in situ detection, though standardised protocols are urgently needed.

6.5 Knowledge Gaps

Critical knowledge gaps persist. Most studies use pristine, laboratory-made polystyrene beads, poorly reflecting the irregular, weathered microplastics found in real environments (Alimi et al., 2022). Research often applies high-dose, short-term exposures, whereas humans face chronic, low-level exposures. Comprehensive assessments of genotoxicity, mutagenicity, and carcinogenicity are still lacking (Rubio et al., 2020).

6.6 Conclusion

In conclusion, the state of the art leaves no doubt: microplastics and nanoplastics are present in the human body, interact synergistically with toxic pollutants, and pose risks across multiple health domains. While definitive causal links in humans remain under investigation, the precautionary principle is warranted. Policymakers should treat the scientific evidence as a call for preventive regulation, harmonised monitoring, and prioritised research funding. The longer gaps persist in knowledge and regulation, the higher the risk of irreversible damage to human health and ecosystems.

Editorial Note on Source Reconciliation

> *This integrated edition merges the February 2026 Policy Briefing with additional material drafted for the companion Report. In doing so, one factual point requires verification before external distribution: the Briefing referred to a 2027 revision of the "Water Framework Directive" under the Water Resilience Strategy, while the Report draft referred to the "Marine Waters Directive" — which is not the official name of any EU legal instrument. Current Commission action includes (a) a targeted revision of the Water Framework Directive itself, launched via a call for evidence in March 2026, and (b) a separate revision of the Marine Strategy Framework Directive announced in the June 2025 Water Resilience Strategy communication (COM(2025) 280). We recommend confirming which instrument is intended before this text is finalised, and using the precise official name.*
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> *Two smaller points were also reconciled: the Report draft's rendering of the Patricia Hunt quotation added the parenthetical "(doing so)" after "they already are", which does not appear in the Briefing's original transcription; this edition retains the Briefing's wording. The Report draft's discussion of fertility (following the Shanna Swan quotation) ended on an incomplete sentence ("Micro-nanoplastics have been found in..."); this has been omitted here pending completion.*

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