Earth: Environmental Sustainability
https://www.sciltp.com/journals/eesus

Perspective

Microplastic Contamination across the Soil-Plant-Human Continuum: Mechanisms and Chain-Specific Governance

Hui Li, Jiawei Hong, Lingjun Zeng and Chen Wang *

School of Environmental and Chemical Engineering, Shanghai University, Shanghai 200444, China
* Correspondence: wangchen0227@shu.edu.cn

How To Cite: Li, H.; Hong, J.; Zeng, L.; et al. Microplastic Contamination across the Soil-Plant-Human Continuum: Mechanisms and Chain-Specific Governance. *Earth: Environmental Sustainability* **2025**, *1*(2), 195–201. https://doi.org/10.53941/eesus.2025.100015

Received: 15 July 2025
Revised: 19 September 2025
Accepted: 9 October 2025
Published: 13 October 2025

Abstract: The widespread contamination of agricultural soils with microplastics (MPs), primarily resulting from plastic mulching and organic amendments, has transformed these systems into long-term sinks for plastic particles. This perspective synthesizes current knowledge on the transport and impacts of MPs across the soil-plant-human continuum. We underscore the pathways by which MPs infiltrate crops via root uptake and foliar deposition, accumulate in edible tissues, and ultimately reach humans through dietary exposure. The associated health risks, including gastrointestinal accumulation, systemic inflammation, endocrine disruption, and the co-transport of adsorbed toxic pollutants, raise pressing concerns for food safety and public health. Moving beyond presence-based assessments, we integrate field-relevant effect thresholds with polymer-specific sorption behaviors to predict cascading impacts along the exposure pathway. Furthermore, we propose a transdisciplinary Soil–Plant–Food (SPF) governance framework that emphasizes actionable strategies for source reduction, process interception, and endpoint regulation. We further call for harmonized monitoring protocols, the establishment of maximum residue limits, and the development of targeted mitigation technologies to enable evidence-based risk management and protect food security and human health.

Keywords: microplastics; food chain; human health; ecotoxicology; agricultural systems

1. Introduction

Plastics, prized for their versatility, durability and low cost, have become integral to modern life, with global production exceeded 430 million tons in 2023 and projected to double within the next two decades [1]. However, widespread plastic use has led to pervasive environmental contamination, particularly through the generation of microplastics (MPs). These particles, defined as <5 mm in size, are recognized as emerging contaminants of concern within agroecosystems. In farmland with 32 years of continuous plastic mulching, MPs reached 10,000 particles/kg in the 0–10 cm surface layer and 3000 particles/kg at 80–100 cm; mulching contributed 33–56% of the soil MPs [2]. In addition, a statistical model based on the UK Rothamsted long-term experiment indicates exponential accumulation of MPs: Under conventional fertilization, concentrations after 50 and 100 years are projected to be about 169 mg/kg and 1159 mg/kg, respectively [3]. These findings suggest sustained inputs of MPs to soils and a tendency for downward migration into deeper layers. The global stock of MPs in agricultural soils is approximately 1.5–6.6 million tonnes, one to two orders of magnitude higher than estimates for the ocean surface [4]. Additionally, a "threshold effect" has been observed in long-term mulched fields: When residual mulch film exceeds ~160–200 kg/ha, the MP generation rate rises sharply (~85%), indicating that beyond a certain soil load, fragmentation and accumulation accelerate [5]. Once introduced into agricultural soils, MPs can translocate through the soil-plant-human continuum, compromising food safety and posing growing risks to human health.

Current research on the ways MPs enter the human body mainly has predominantly focused on drinking water and air. For drinking water, bottled water is mainly composed of nanoparticles (NPs), with recent single-particle imaging reporting a median concentration of ~2.4×10^5 particles per liter, ~90% of which are NPs [6]. Inhalation exposure may be comparable to, or even exceed, ingestion at the population level, and indoor air measurements using a breathing thermal manikin indicate rates of up to ~11 particles per hour in certain environment [7]. While ingestion from plant-based foods is typically lower, most market samples report ~3 (±1.6) particles per gram, which should not be underestimated [8]. Therefore, studies tracing the soil-plant-human pathway are highly necessary. This perspective moving beyond presence-based narratives, outlines current understanding of the transport pathways and cascading biological effects of MPs in terrestrial food systems, by (i) combining field-based effect thresholds with polymer- and aging-specific sorption to predict lasting, chain-wide impacts on soil function, plant uptake, and human exposure; (ii) summarizing human toxic effects of MPs, linking exposure routes to clear health endpoints and simple mechanisms; and (iii) building a chain-specific governance plan for the soil–plant–human continuum, with practical rules for monitoring, choosing actions, and effect evaluation across farms and food supply. We further operationalize these elements by proposing measurable indicators and to support risk-based management.

2. Agricultural Soils: Terminal Sinks and Reservoirs for Microplastics

Agricultural soils are emerging as critical sinks for MPs receiving inputs from diverse sources including degradation of agricultural films, irrigation infrastructure, atmospheric deposition, sewage sludge, and compost application [9,10]. Field-reported MP abundances span approximately three orders of magnitude (~10^2–10^5 particles/kg dry soil) [11]. Detectable changes in aggregate stability and soil hydraulic properties have been reported around the 10^3–10^4 particles/kg. In long-term biosolids-amended fields, elevated inventories can persist for ≥20 years [12]. These apparent thresholds are influenced by particle size (nano- vs. microscale), shape (fibers, films, fragments), weathering/oxidation, and soil texture [13,14]. Pot experiments show that additions of polyester fibers at 0.05–0.40% (*w*/*w*) decrease water-stable soil aggregates and alter soil bulk density and water-holding capacity, in contrast, polyethylene (PE) at 0.25–2.0% (*w*/*w*) can alter soil bulk density and significantly modify the microbial activity-soil aggregation relationship [15]. These changes destabilize microbial communities, reduce soil fertility, and undermine agroecosystem resilience [16–18]. Moreover, Polymer chemistry influence adsorption behavior and co-contaminant interactions. Surfaces with aromatic or polar functionalities (e.g., PS, PET) can participate in π–π stacking and hydrogen bonding, exhibiting enhanced affinity toward certain π-conjugated hydrophobic pesticides [19], whereas adsorption to nonpolar PE is dominated by partitioning [20]; meanwhile, environmental aging (oxidation/ photo-oxidation) generally increases surface area and oxygen-containing functional groups, thereby increasing the overall sorptive capacity for diverse organic pollutants under field conditions and potentially amplifying co-exposure [21]. Despite their invisibility, MPs in soil initiate a cascade of biological effects that propagate through the food chain, beginning with plant uptake.

3. Plant Uptake and Phytotoxicity: The Stealth Transmission from Crops to Food

MPs enter agricultural crops primarily through two pathways: (1) Root uptake, where MPs infiltrate root tissues through apoplastic and symplastic routes, accumulate in xylem vessels, and are subsequently translocated to above-ground organs [22]; (2) Foliar deposition, where airborne MPs (<100 nm) deposit on leaf surfaces and enter through stomata or cuticular microfissures [23,24]. Once internalized via roots, MPs can move into vascular bundles via intercellular cracks or plasmodesmatal connections, and are further disturbted to aboveground tissues by transpiration-driven apoplastic flow [22,25]. Similarly, MPs deposited on the phyllosphere may access vascular tissues through apoplastic pathways; however, rootward translocation efficiency is notably low, typically not exceeding 5% [23]. MPs predominantly accumulate within vascular tissues of roots, stems, and leaves (Figure 1) Among edible organs, leafy tissues generally show higher internal burdens [24]. In contrast, root/tuber crops (e.g., carrots, potatoes) typically exhibit lower internalization, with risks associated with surface adhesion and localized accumulation near the root cap, suggesting a lower but non-zero consumption risk [26]. In addition, evidence from soil-based pot experiments shows that 0.2–2% (*w*/*w*) MPs mixed into agricultural soils can alter plant performance across multiple traits, including shoot and root biomass, and root shoot allocation. These effects are influenced by polymer type, particle shape, and concentration [27]. At 0.02–2% (*w*/*w*), PBAT MPs significantly decreased rhizosphere-available nutrients in pakchoi and more strongly disrupted microbial functions, whereas PE at the same dose range showed no significant toxicity to plants [28]. These effects jeopardize crop productivity, nutrient composition, and ultimately, food security. Moreover, MPs may undergo further fragmentation during postharvest processing and cooking. High temperature, mechanical shear, and abrasion can accelerate fragmentation into NPs [29,30] and promote desorption of sorbed pesticides/additives into food, increasing the risks of human exposure through dietary intake [31]. In pot experiments, polyethylene (PE) MPs significantly increased Cd uptake by lettuce and exhibited combined toxicity with Cd [32]. Conversely, washing food before consumption can effectively reduce MP levels, studies have shown that rinsing supermarket rice can lower MPs by 20–40% [33].

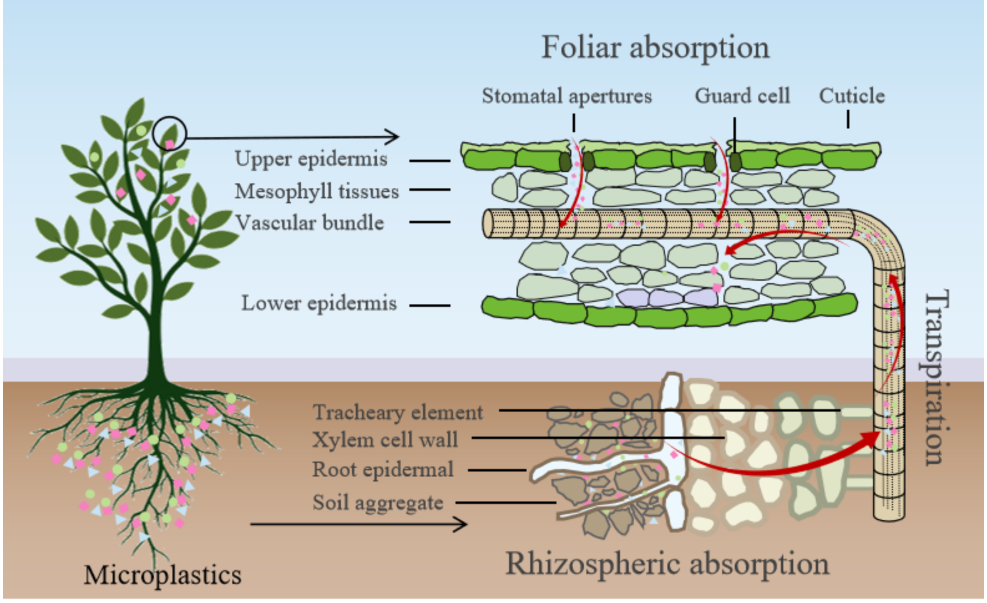

Figure 1. Principal uptake pathways of microplastics in plants via root and foliar infiltration.

4. Human Health Risks: From Ingestion to Systemic and Toxic Effects

MPs enter the human body primarily via ingestion of contaminated foodstuffs and accumulate in the gastrointestinal tract, liver, intestines, and other organs [34,35]. Studies have shown that, compared to healthy controls (28.0 items/g dry weight, dw), patients with inflammatory bowel disease (IBD) had significantly higher fecal MPs loads (41.8 items/g dw), which tracked positively with disease severity [36]. Within the gut, MPs interact with gut-associated lymphoid tissue, triggering immune dysregulation via NF-κB activation and inflammatory cytokine release, which contribute to epithelial injury, cellular necrosis, and systemic inflammation [37]. Polymer aging/eco-corona formation further modulates surface interactions relevant to gastrointestinal desorption and tissue partitioning [38]. Notably, MPs have also been detected in placental tissues, suggesting vertical transfer to fetuses and increased exposure risk in neonates [39,40]. Multiple human biomonitoring studies and authoritative assessments indicate that the accumulation potential of MPs in human tissues is dependent on particle characteristics. For instance, European Food Safety Authority (EFSA) reports that particles >150 μm are rarely absorbed, while those <1.5 μm can penetrate deeper tissues. Furthermore, specific polymers (e.g., PE, PVC) have been detected in blood, the placenta (5–10 μm particles), lungs (≥3 μm particles/fibers), and carotid atherosclerotic plaques [41], these observations are consistent with the established mechanisms whereby a particle's ability to translocate across biological barriers and be retained within tissues is relevant to its size, morphology, and surface chemistry [42]. In summary, assessing the health risks of plant-derived MPs hinges on their bioavailability in humans—that is, their ability to cross the intestinal barrier and enter systemic circulation after ingestion. This process is primarily regulated by three factors: (1) Source Characteristics: The size, shape, polymer type, and surface chemistry of MPs present in plant tissues (resulting from environmental exposure and internal transformation within the plant; (2) Influence of Food Processing: Processes such as cooking, cutting, and chewing may significantly alter the physicochemical properties of MPs (e.g., degradation, aggregation, release of additives), thereby enhancing or diminishing their bioavailability; (3) Human Gastrointestinal Environment: The chemical actions of digestive fluids (pH, enzymes) and mechanical motility of the gastrointestinal tract may further modify MPs, influencing their ultimate bioactivity. The adverse health effects of MPs can be attributed to three primary mechanisms: (1) Mechanical abrasion: The irregular, angular surfaces of MPs can physically damage intestinal epithelial cells, disrupting mucosal integrity and barrier function [43]; (2) Chemical toxicity: MPs carry intrinsic plastic additives (e.g., plasticizers, flame retardants) as well as adsorbed environmental pollutants (e.g., pesticides), many of which possess endocrine-disrupting properties. Multiple studies have shown that MPs can increase the bioavailability of metals such as Cu, Pb, and Cd [44]. In simulated gastrointestinal fluids, BPA, PAHs, and PCBs rapidly desorb from MPs such as PS, PP, and PA, indicating that *in vivo* re-release after ingestion can increase bioavailability [45,46]. Compared to bare MPs, MP-pollutant complexes can amplify toxic outcomes (e.g., inflammation, endocrine disruption) through a surface enrichment → gastrointestinal desorption → localized/systemic exposure pathway, potentially affecting long-term reproductive and metabolic function [45,47,48]; (3) Bioaccumulation: Due to inefficient clearance, MPs tend to persist in biological tissues, progressively accumulating in vital organs and tissues. Chronic retention may contribute to sustained inflammation and an increased risk of neoplastic transformation [49]. Moreover, existing literature has developed reusable scenario parameter tables stratified by population and behavior (e.g., adults/children, diet composition, time spent indoor/outdoors), conducted multidimensional data harmonization for ingestion and inhalation pathways and medium characteristics (particle size, count/mass, surface area, and other dose metrics), and applied probabilistic methods to generate external-exposure-to-internal-dose distributions for each scenario [50]. By population-level estimates, annual intake is about 3.9–5.2 × 104 particles per person [7]. The median MP intake rates are 553 particles/capita/day (184 ng/capita/day) for children and 883 particles/capita/day (583 ng/capita/day) for adults [51]. From MP detection in plant-based foods, to human fecal MP burdens, to *in vivo* tissue detection, this critical evidence chain must be established to definitively link dietary exposure to health risks. Currently, human health outcome data are limited, we discuss potential health effects as mechanistically plausible hypotheses, emphasizing the need for future epidemiological studies to validate this exposure-risk pathway. These findings underscore the need for a whole-chain management framework based on risk assessment, particularly for vulnerable populations such as infants, pregnant women, and agricultural communities.

5. Governance Framework: Transdisciplinary Integration and Full-Chain Regulation

Addressing MP contamination across the soil–plant–human interface demands an integrated governance framework incorporating source prevention, process interception, and terminal risk control. Key recommendations include: (1) Source reduction: Implement differentiated regulatory measures that prioritize MPs with high sorptive potential in real-world environments (e.g., PE, PS [52,53]) and those with high ecotoxicity (e.g., PBAT [28]). Because fragmentation can outpace mineralization under suboptimal conditions, incomplete degradation of bioplastics may temporarily increase MP loads. Therefore, field mass-balance verification is required before any scale-up. The adoption of soil-biodegradable agricultural plastics should be promoted only when their performance is field-validated, and their end-of-life pathways must aligned with the receiving environment [54]. Moreover, government should standardize plastic waste management practices and limit exogenous MP inputs into agroecosystems. Before New York's plastic bag ban, the city spent over $12 million annually managing residential single-use bags, and Material Recovery Facilities (MRFs) statewide incurred $0.3–1.0 million per facility per year in extra operation and maintenance (O & M) costs due to bag tangling. After the ban, these costs were largely avoided or significantly reduced [55]; (2) Process interception: Deploy engineered rhizosphere microbiome to enhance plant resistance to MPs and select cultivate crop varieties with low-bioaccumulation potential [56]. Considering economic efficiency and sustainability, we recommend prioritizing differentiated source controls in the short-to-mid term and targeted pilots for engineered microbes/low-uptake cultivars thereafter; (3) End-point regulation: Establish MP residue inventories, define maximum residue limits (MRLs) in crops, we suggest considering intestinal barrier inflammation and hepatic metabolic dysregulation as key candidate endpoints, alongside with PBK modeling and probabilistic exposure assessment, to establish tolerable daily intake (TDI) and develop dietary exposure reference values for human health risk assessment [36,57]. Along the soil–plant–human pathway, we target three control points, collectively named SPF (Soil-Plant-Food): S refers to controlling field inputs and measuring field-based abrasion and fragmentation of agricultural plastics and biosolids; P refers to trialing root-zone chemical barriers and selecting cultivars that minimize particle uptake and internal partitioning; F refers to standardizing post-harvest trimming, peeling, and rinsing, and avoiding high-shear processing that increases fragmentation. Moreover, for farmers chronically exposed to MPs in agricultural systems, we recommend developing standardized task-based exposure assessment protocols (personal air sampling, settled dust metrics, and dermal load indicators) across representative farm tasks; creating job-exposure matrices for agricultural plastics to identify high-exposure tasks and seasons.; and integrating occupational safeguards into farm certification and plastic-waste take-back scheme [43,58,59]. These efforts would bridge current data gaps and provide a foundation for evidence-based occupational guidance and regulation for MPs in agricultural settings. Given the transboundary nature of MP pollution, international coordination should be reinforced through binding multilateral agreements and harmonized regulatory instruments. We advocate for future research priorities that address current knowledge gaps, including (1) prioritize quantifying the bioaccessible fraction of dietary MPs from plants and elucidating their fate in the human gastrointestinal tract to move beyond speculative risk assessment and towards evidence-based conclusions; (2) evaluation of chronic effects under human-relevant exposure scenarios, with early-life susceptibility endpoints; (3) development of targeted mitigation technologies, such as root-zone chemo-barriers and genome-edited low-uptake cultivars. Quantifying long-term accumulation dynamics, potential saturation, and cross-compartmental scaling of the soil reservoir remains an open task for future work integrating inventories, fate models, and health metrics. To facilitate evidence-based policymaking, a globally coordinated monitoring network is urgently needed to integrate MP residue thresholds into *Codex Alimentarius*, ensuring alignment with the United Nations Sustainable Development Goals (SDGs).

Author Contributions

C.W. and H.L.: writing-review & editing, supervision, resources, funding acquisition; J.H.: writing-original draft, methodology, investigation; L.Z.: writing-review & editing. All authors have read and agreed to the published version of the manuscript.

Funding

This work was jointly supported by the National Natural Science Foundation of China (42125706 and 42477474), the National Key Research and Development Plan (2023YFE0115200), and the Chenguang Program of Shanghai Education Development Foundation and Shanghai Municipal Education Commission (24CGA44). We also thank the anonymous reviewers for their valuable comments and suggestions on this paper.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflicts of Interest

Given the role as Editorial Board Member, Chen Wang had no involvement in the peer review of this paper and had no access to information regarding its peer-review process. Full responsibility for the editorial process of this paper was delegated to another editor of the journal.

Use of AI and AI-assisted Technologies

No AI tools were utilized for this paper.

References

1. Deng, P.; Hu, X.; Wang, R.; et al. Spatial Risks of Microplastics in Soils and the Cascading Effects Thereof. *Environ. Sci. Technol.* **2025**, *59*, 10299–10309.
2. Li, S.; Ding, F.; Flury, M.; et al. Macro- and microplastic accumulation in soil after 32 years of plastic film mulching. *Environ. Pollut.* **2022**, *300*, 118945.
3. Meizoso-Regueira, T.; Fuentes, J.; Cusworth, S.J.; et al. Prediction of future microplastic accumulation in agricultural soils. *Environ. Pollut.* **2024**, *359*, 124587.
4. Kedzierski, M.; Cirederf-Boulant, D.; Palazot, M.; et al. Continents of plastics: An estimate of the stock of microplastics in agricultural soils. *Sci. Total Environ.* **2023**, *880*, 163294.
5. Shufeng, Z.; Xiaoqing, L.; Xiao, Y.; et al. Dynamics of residual film mass and microplastic abundance in long-term plastic-mulched cotton fields. *Front. Agric. Sci. Eng.* **2026**, *13*, 25627.
6. Qian, N.; Gao, X.; Lang, X.; et al. Rapid single-particle chemical imaging of nanoplastics by SRS microscopy. *Proc. Natl. Acad. Sci. USA* **2024**, *121*, e2300582121.
7. Cox, K.D.; Covernton, G.A.; Davies, H.L.; et al. Human Consumption of Microplastics. *Environ. Sci. Technol.* **2019**, *53*, 7068–7074.
8. Aydın, R.B.; Yozukmaz, A.; Şener, İ.; et al. Occurrence of Microplastics in Most Consumed Fruits and Vegetables from Turkey and Public Risk Assessment for Consumers. *Life* 2023, *13*, 1686.
9. Guo, J.-J.; Huang, X.-P.; Xiang, L.; et al. Source, migration and toxicology of microplastics in soil. *Environ. Int.* **2020**, *137*, 105263.

10. Weithmann, N.; Möller, J.N.; Löder, M.G.J.; et al. Organic fertilizer as a vehicle for the entry of microplastic into the environment. *Sci. Adv.* **2018***, 4*, eaap8060.
11. Scheurer, M.; Bigalke, M. Microplastics in Swiss Floodplain Soils. *Environ. Sci. Technol.* **2018**, *52*, 3591–3598.
12. Weber, C.J.; Santowski, A.; Chifflard, P. Investigating the dispersal of macro- and microplastics on agricultural fields 30 years after sewage sludge application. *Sci. Rep.* **2022**, *12*, 6401.
13. Ramage, S.J.F.F.; Coull, M.; Cooper, P.; et al. Microplastics in agricultural soils following sewage sludge applications: Evidence from a 25-year study. *Chemosphere* **2025**, *376*, 144277.
14. Weber, C.J.; Kundel, D.; Fliessbach, A.; et al. Baseline levels of microplastics in agricultural soils obscure the effects of additional microplastics from recycled fertilizers. *Microplastics Nanoplastics* **2025**, *5*, 30.
15. de Souza Machado, A.A.; Lau, C.W.; Till, J.; et al. Impacts of Microplastics on the Soil Biophysical Environment. *Environ. Sci. Technol.* **2018**, *52*, 9656–9665.
16. He, L.; Li, Z.; Jia, Q.; et al. Soil microplastics pollution in agriculture. *Science* **2023**, *379*, 547–547.
17. Rillig, M.C.; Lehmann, A. Microplastic in terrestrial ecosystems. *Science* **2020**, *368*, 1430–1431.
18. Huang, W.; Xia, X. Element cycling with micro(nano)plastics. *Science* **2024**, *385*, 933–935.
19. Fischer, F.C.; Cirpka, O.A.; Goss, K.-U.; et al. Application of Experimental Polystyrene Partition Constants and Diffusion Coefficients to Predict the Sorption of Neutral Organic Chemicals to Multiwell Plates in *in Vivo* and *in Vitro* Bioassays. *Environ. Sci. Technol.* **2018**, *52*, 13511–13522.
20. Lohmann, R. Critical Review of Low-Density Polyethylene's Partitioning and Diffusion Coefficients for Trace Organic Contaminants and Implications for Its Use As a Passive Sampler. *Environ. Sci. Technol.* **2012**, *46*, 606–618.
21. Castan, S.; Henkel, C.; Hüffer, T.; et al. Microplastics and nanoplastics barely enhance contaminant mobility in agricultural soils. *Commun. Earth Environ.* **2021**, *2*, 193.
22. Luo, Y.; Li, L.; Feng, Y.; et al. Quantitative tracing of uptake and transport of submicrometre plastics in crop plants using lanthanide chelates as a dual-functional tracer. *Nat. Nanotechnol.* **2022**, *17*, 424–431.
23. Jiang, X.; White, J.C.; He, E.; et al. Foliar Exposure of Deuterium Stable Isotope-Labeled Nanoplastics to Lettuce: Quantitative Determination of Foliar Uptake, Transport, and Trophic Transfer in a Terrestrial Food Chain. *Environ. Sci. Technol* **2024**, *58*, 15438–15449.
24. Li, Y.; Zhang, J.; Xu, L.; et al. Leaf absorption contributes to accumulation of microplastics in plants. *Nature* **2025**, *641*, 666–673.
25. Liu, Y.; Guo, R.; Zhang, S.; et al. Uptake and translocation of nano/microplastics by rice seedlings: Evidence from a hydroponic experiment. *J. Hazard. Mater.* **2022**, *421*, 126700.
26. Parkinson, S.J.; Tungsirisurp, S.; Joshi, C.; et al. Polymer nanoparticles pass the plant interface. *Nat. Commun.* **2022**, *13*, 7385.
27. de Souza Machado, A.A.; Lau, C.W.; Kloas, W.; et al. Microplastics Can Change Soil Properties and Affect Plant Performance. *Environ. Sci. Technol.* **2019**, *53*, 6044–6052.
28. Han, Y.; Teng, Y.; Wang, X.; et al. Biodegradable PBAT microplastics adversely affect pakchoi (*Brassica chinensis* L.) growth and the rhizosphere ecology: Focusing on rhizosphere microbial community composition, element metabolic potential, and root exudates. *Sci. Total Environ.* **2024**, *912*, 169048.
29. Hernandez, L.M.; Xu, E.G.; Larsson, H.C.E.; et al. Plastic Teabags Release Billions of Microparticles and Nanoparticles into Tea. *Environ. Sci. Technol.* **2019**, *53*, 12300–12310.
30. Yadav, H.; Khan, M.R.H.; Quadir, M.; et al. Cutting Boards: An Overlooked Source of Microplastics in Human Food? *Environ. Sci. Technol.* **2023**, *57*, 8225–8235.
31. Li, D.; Shi, Y.; Yang, L.; et al. Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation. *Nat. Food* **2020**, *1*, 746–754.
32. Wang, F.; Wang, X.; Song, N. Polyethylene microplastics increase cadmium uptake in lettuce (*Lactuca sativa* L.) by altering the soil microenvironment. *Sci. Total Environ.* **2021**, *784*, 147133.
33. Dessì, C.; Okoffo, E.D.; O'Brien, J.W.; et al. Plastics contamination of store-bought rice. *J. Hazard. Mater.* **2021**, *416*, 125778.
34. Lin, S.; Zhang, H.; Wang, C.; et al. Metabolomics Reveal Nanoplastic-Induced Mitochondrial Damage in Human Liver and Lung Cells. *Environ. Sci. Technol.* **2022**, *56*, 12483–12493.
35. Zhang, Q.; Xu, E.G.; Li, J.; et al. A Review of Microplastics in Table Salt, Drinking Water, and Air: Direct Human Exposure. *Environ. Sci. Technol.* **2020**, *54*, 3740–3751.
36. Yan, Z.; Liu, Y.; Zhang, T.; et al. Analysis of Microplastics in Human Feces Reveals a Correlation between Fecal Microplastics and Inflammatory Bowel Disease Status. *Environ. Sci. Technol.* **2022**, *56*, 414–421.
37. Yang, Q.; Peng, Y.; Wu, X.; et al. Microplastics in human skeletal tissues: Presence, distribution and health implications. *Environ. Int.* **2025**, *196*, 109316.
38. Yao, S.; Li, X.; Wang, T.; et al. Soil Metabolome Impacts the Formation of the Eco-corona and Adsorption Processes on Microplastic Surfaces. *Environ. Sci. Technol.* **2023**, *57*, 8139–8148.

39. Ragusa, A.; Svelato, A.; Santacroce, C.; et al. Plasticenta: First evidence of microplastics in human placenta. *Environ. Int.* **2021**, *146*, 106274.
40. Chen, Z.; Yin, X.; Geng, Y.-Q.; et al. Subchronic Exposure to Polystyrene Nanoplastics Disrupts Placental Development and Calcium Homeostasis: Insights from *In Vivo* and *In Vitro* Models. *ACS Nano* **2025**, *19*, 13825–13841.
41. Marfella, R.; Prattichizzo, F.; Sardu, C.; et al. Microplastics and Nanoplastics in Atheromas and Cardiovascular Events. *Engl. J. Med.* **2024**, *390*, 900–910.
42. EFSA Panel on Contaminants in the Food Chain (CONTAM). Presence of microplastics and nanoplastics in food, with particular focus on seafood. *EFSA J.* **2016**, *14*, e04501.
43. Wright, S.L.; Kelly, F.J. Plastic and Human Health: A Micro Issue? *Environ. Sci. Technol.* **2017**, *51*, 6634–6647.
44. An, Q.; Zhou, T.; Wen, C.; et al. The effects of microplastics on heavy metals bioavailability in soils: A meta-analysis. *J. Hazard. Mater.* **2023**, *460*, 132369.
45. Mohamed Nor, N.H.; Koelmans, A.A. Transfer of PCBs from Microplastics under Simulated Gut Fluid Conditions Is Biphasic and Reversible. *Environ. Sci. Technol.* **2019**, *53*, 1874–1883.
46. Li, W.; Zu, B.; Li, L.; et al. Desorption of bisphenol A from microplastics under simulated gastrointestinal conditions. *Front. Mar. Sci.* **2023**, *10*, 1195964.
47. Zhang, Y.; Men, J.; Yin, K.; et al. Activation of gut metabolite ACSL4/LPCAT3 by microplastics in drinking water mediates ferroptosis via gut–kidney axis. *Commun. Biol.* **2025**, *8*, 211.
48. Stevens, S.; McPartland, M.; Bartosova, Z.; et al. Plastic Food Packaging from Five Countries Contains Endocrine- and Metabolism-Disrupting Chemicals. *Environ. Sci. Technol.* **2024**, *58*, 4859–4871.
49. Kim, D.; Kim, D.; Kim, H.-K.; et al. Organ-specific accumulation and toxicity analysis of orally administered polyethylene terephthalate microplastics. *Sci. Rep.* **2025**, *15*, 6616.
50. Lane, T.; Wardani, I.; Koelmans, A.A. Exposure scenarios for human health risk assessment of nano- and microplastic particles. *Microplastics Nanoplastics* **2025**, *5*, 28.
51. Mohamed Nor, N.H.; Kooi, M.; Diepens, N.J.; et al. Lifetime Accumulation of Microplastic in Children and Adults. *Environ. Sci. Technol.* **2021**, *55*, 5084–5096.
52. Wang, W.; Wang, J. Different partition of polycyclic aromatic hydrocarbon on environmental particulates in freshwater: Microplastics in comparison to natural sediment. *Ecotoxicol. Environ. Saf.* **2018**, *147*, 648–655.
53. Rochman, C.M.; Manzano, C.; Hentschel, B.T.; et al. Polystyrene plastic: A source and sink for polycyclic aromatic hydrocarbons in the marine environment. *Environ. Sci. Technol.* **2013**, *47*, 13976–13984.
54. Nelson, T.F.; Baumgartner, R.; Jaggi, M.; et al. Biodegradation of poly(butylene succinate) in soil laboratory incubations assessed by stable carbon isotope labelling. *Nat. Commun.* **2022**, *13*, 5691.
55. New York City Department of Sanitation. Single-Use Plastic Carryout Bags. Available online: https://www.nyc.gov/site/dsny/businesses/materials-handling/single-use-plastic-bags.page (accessed on 12 September 2025).
56. Sheng, D.; Jing, S.; He, X.; et al. Plastic pollution in agricultural landscapes: An overlooked threat to pollination, biocontrol and food security. *Nat. Commun.* **2024**, *15*, 8413.
57. Deng, Y.; Chen, H.; Huang, Y.; et al. Long-Term Exposure to Environmentally Relevant Doses of Large Polystyrene Microplastics Disturbs Lipid Homeostasis via Bowel Function Interference. *Environ. Sci. Technol.* **2022**, *56*, 15805–15817.
58. Allen, S.; Allen, D.; Phoenix, V.R.; et al. Atmospheric transport and deposition of microplastics in a remote mountain catchment. *Nat. Geosci.* **2019**, *12*, 339–344.
59. Evangelou, I.; Tatsii, D.; Bucci, S.; et al. Atmospheric Resuspension of Microplastics from Bare Soil Regions. *Environ. Sci. Technol.* **2024**, *58*, 9741–9749.