Proceedings of the 4th International Conference on Modern Medicine and Global Health
DOI: 10.54254/2753-8818/2026.LA31718

Characteristics of Occurrence, Ecological Processes, and Health Impacts of Microplastics in the "Environment-Organism-Human Body" Continuum

Yang Cao

College of Environment and Resources, Xiangtan University, Xiangtan, China
202305820906@smail.xtu.edu.cn

Abstract. As a new type of persistent pollutant, microplastics pose significant ecological risks to both aquatic and terrestrial ecosystems and have become an imminent global environmental problem. These particles infiltrate the food chain through a complex process of transmediated migration, entering the bodies of organisms with high nutrient levels, including humans, through respiration and diet. Despite the urgency of the situation, the assessment of the health risks of microplastics is still in its early stages. In particular, the systematic understanding of the "trans-media migration-bioaccumulation" relationship is limited, and studies focusing on a single environmental medium are difficult to fully reveal exposure pathways and health impact chains. This paper systematically reviews recent advances in environmental monitoring, laboratory simulations, and epidemiological research. It aims to track the migration patterns of microplastics in water, soil and atmospheric environments through in vitro cell experiments and animal model studies, analyze the bioaccumulation and amplification of microplastics in the plant and animal food chain, and explore the toxicological mechanism of microplastics. Studies have shown that microplastics can spread globally through cross-vector migration, gradually accumulate in organisms, and exhibit food chain amplification effects. Long-term exposure to microplastics can cause chronic damage to key organs in the body, such as the cardiovascular and respiratory systems. Therefore, controlling microplastic pollution is a complex systemic challenge that urgently requires multi-dimensional, cross-disciplinary synergistic strategies and global cooperation.

Keywords: Microplastics, Toxicity mechanisms, Risk quantification, Cross-media migration, Health effects

1. Introduction

Microplastics refer to plastic fragments, particles, or fibers smaller than 5mm [1]. Due to their widespread presence, especially in the oceans-an estimated 5.1 trillion (UN News & Day)-microplastics have been dubbed "PM2.5 in the ocean" and have become the focus of global environmental science research. The overproduction, widespread use, and improper disposal of plastic products have led to the accumulation of microplastics (MPs, 5 mm) and nanoplastics (NPs,

DOI: 10.54254/2753-8818/2026.LA31718

1000 nm) in the environment [2]. Microplastics of different sizes show significant differences in environmental migration, bioaccumulation, and toxicity mechanisms. In the natural environment, microplastics migrate mainly through wind, precipitation, surface runoff, and rivers in terrestrial, freshwater, ocean, and atmosphere, and water is the main medium through which they move [3]. Smaller plastic particles have a larger specific surface area and more active sites, making them more likely to adsorb other contaminants. Nanoplastics, with their smaller size and lipophilic surface, can theoretically penetrate the biological epithelial barrier and enter the tissue space, increasing local exposure and potential health risks to the organism [4].

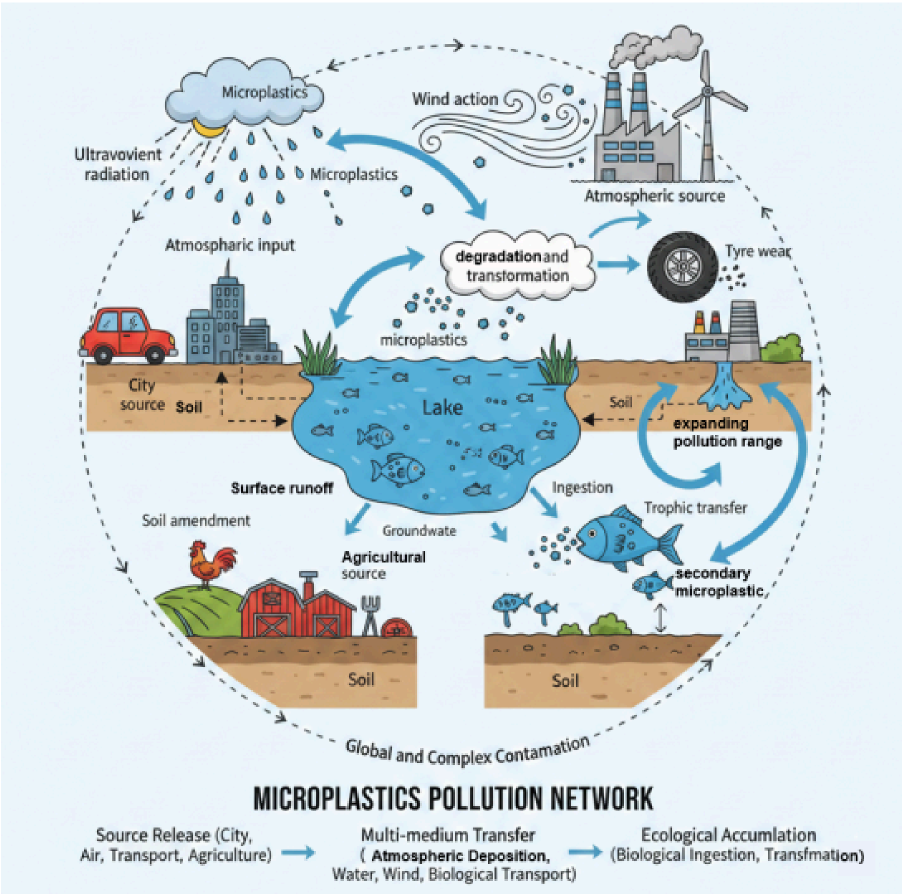

Figure 1. Sources of microplastics in ecosystems and their interactions with the environment

The global problem of plastic pollution is getting worse. A large amount of plastic debris in the environment degrades into secondary microplastics due to weathering, photodegradation, and biodegradation [5]. These microplastics are then widely distributed in various environmental media, including the atmosphere, water bodies, and soil, posing a significant threat to ecosystem balance and human health [6].

Recognizing the prevalence of microplastics and their potential harms, China has prioritized them in the initial "List of New Pollutants for Priority Control (2023) [7]." Microplastics, as emerging pollutants, exhibit three main characteristics: persistence (P), bioaccumulation (B), and toxicity (T) [8]. Once microplastics are ingested through food chain enrichment and other routes, they can cause multisystem toxic effects, such as intensified inflammatory responses. Some microplastics are able to penetrate cells, such as M cells, enter the lymphatic or circulatory system, and accumulate in vital organs such as the liver and kidneys, which can lead to long-term damage to the immune system and

DOI: 10.54254/2753-8818/2026.LA31718

endocrine system [9]. Therefore, studying the entire life cycle of microplastics-from their generation and environmental migration to bioaccumulation and human exposure-is essential to develop effective pollution prevention strategies and ensure ecological and human health.

The study focuses on the following issues:

(1)The presence level and interface behavior of microplastics in environmental media: quantify the abundance, particle size distribution and chemical composition of microplastics in different media, and analyze the migration and transformation between media.

(2) Migration, vector effects and ecotoxicology of microplastics in ecosystems: trace the transfer pathways and biomagnification of microplastics in the food chain, and reveal their comprehensive ecotoxicology as pollutant carriers.

(3) Human exposure, health risks and governance: Identify the main pathways through which humans are exposed to microplastics, and how the particles affect health. Develop a microplastic risk assessment model that incorporates environmental fate, bioaccumulation and health effects. Propose a systematic strategy for controlling microplastic pollution, focusing on source reduction, process interruption and end-of-pipe treatment. This approach is designed to provide scientific foundation and policy recommendations for preventing and controlling microplastic pollution.

2. Sources, aging, and distribution of microplastics in the environment

Microplastics originate from many sources and are classified as primary (made for a particular purpose like microbeads in cosmetics) and secondary (made from larger plastic waste) [10]. As plastics are used and recycled, they contaminate water, soil, air, and air, by physical abrasion, photodegradation, biodegradation. The aging process of microplastics in the environment is physical, chemical and biological processes, changing their surface properties, size, shape, and chemical composition [11], influencing their environmental behaviour and biological toxicity [12].

Microplastics, derived from a variety of sources, are extensively dispersed across numerous environmental media, including land, oceans, the atmosphere, freshwater, soil, and drinking water distribution systems (DWDS). These sources encompass both primary and secondary origins. Specifically:

Terrestrial microplastics originate from additives in cosmetics and detergents, synthetic fibers released during textile washing, and fragments produced by natural weathering and abrasion of waste such as bags and packaging. Marine sources include particles from ship coatings, fibers shed from fishing nets used in aquaculture, and further fragmentation of land-derived plastic waste. In the atmosphere, primary sources are microplastic aerosols emitted during plastic production; additional inputs arise when microplastics are lofted from soil surfaces by wind or transferred from the ocean to air by bursting bubbles. Freshwater systems receive microplastics from aquaculture feed and industrial wastewater discharge; secondary sources form when plastic waste degrades in water through scouring and biological processes. Soils, which act as important sinks for microplastics, receive primary inputs from residues of agricultural plastic films and additives in organic fertilizers, while secondary sources include material produced by microbial activity and physical fragmentation. In drinking water distribution systems (DWDS), primary sources comprise lubricants containing microplastics used in pipeline maintenance and release from aging pipeline materials; secondary sources arise from corrosion and abrasion of inner pipe walls and from deposition and re-suspension of microplastics present in source water [13].

DOI: 10.54254/2753-8818/2026.LA31718

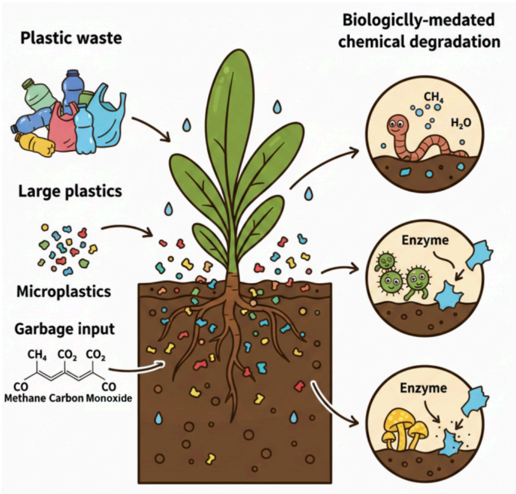

Figure 2. Presents a schematic diagram illustrating the degradation process of plastic waste and the role microplastics play in soil

Microplastics are found in drinking water distribution systems (DWDS) and their health risks have been well studied [13]. Flow disturbances in pipelines can resuspend settled microplastics and introduce them into tap water. Microplastic transport in fresh water depends on particle size, shape, density, biofouling, hydrodynamics, and water chemistry (pH, salinity) [14]. We need to know how microplastics release and migrate into drinking water systems.

3. Ecotoxicological mechanisms and cascade effects of microplastics

The ecotoxicological mechanisms of microplastics are highly complex. They initiate a cascade effect through various interactions, impacting the functions of individuals, populations, communities, and entire ecosystems.

microplastics affect a range of ecological receptors, such as microorganisms, planktonic and benthic insects, fish, birds, and terrestrial plants. Ingestions on decomposer microbes can affect metabolism and change community structure. Zooplankton and benthic animals often eat microplastics intentionally and can affect growth and reproduction and in some cases suppress phytoplankton photosynthesis. Fish eat microplastics either by direct ingestion or by eating contaminated prey, leading to tissue damage, neurotoxicity, metabolic disturbance and gut microbiota dysbiosis [15]. Higher trophic birds also have the risk of consuming microplastics. Plants take up microplastics through roots, and a disturbance of growth and development.

Transfer and biomagnetisation of microplastics in food webs are responsible for their ecological risk, particularly in marine systems [16-18]. Phytoplankton acquire microplastics by surface adsorption or cell internalization, which can impair photosynthesis and damage cells. When zooplankton feed on these contaminated primary producers, microplastics rise on the food chain and can reduce growth and fertility of zooplankton. As main link in marine food webs, zooplankton feed by small fish, which allows microplastics to reach higher trophic levels. The predator–prey sequence of “big fish eat small fish” is also responsible for the transfer and accumulation of microplastics. Human consumption of contaminated seafood is ultimately the final link in this transfer chain and microplastic concentrations can increase with trophic level, increasing risk for high-trophic organisms such as humans.

DOI: 10.54254/2753-8818/2026.LA31718

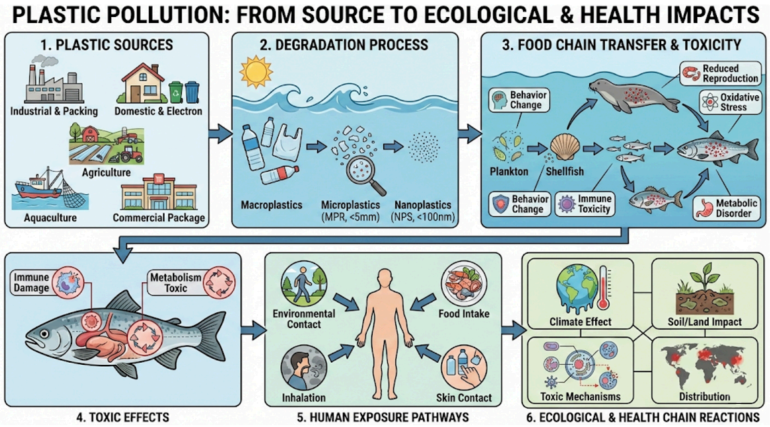

Figure 3. Sources, transmission pathways, and impacts on the ecosystem and health of microplastics

4. Human exposure pathways, doses, and health effects

The exposure routes, doses, and health effects of microplastics (MPs) and nanoplastics (NPs) on the human body have emerged as a leading topic in environmental health research.

4.1. Exposure pathways and contribution weights

Human exposure to microplastics primarily occurs through ingestion, inhalation, and skin contact [18], with each route varying in significance. Research shows that dietary intake is the most significant exposure pathway. People ingest microplastics by consuming shellfish, salt, honey, and bottled water [19]. The second major route is inhalation. Microplastic particles in the air, especially in urban or industrial areas, can enter the respiratory system. Key sources of inhalation include fibers from furniture and textiles indoors and particles from tire wear in road dust. In contrast, skin contact contributes less to exposure, mainly through personal care products with plastic microbeads, but its risk should not be ignored.

4.2. Human health effects and toxicological mechanisms

Micro/nanoplastics, as pervasive environmental pollutants, pose growing threats to human health [20-23]. Once these tiny particles enter the body, they can travel through the bloodstream and accumulate in various organs [20-24]. Researchers have identified microplastics in biological samples, including human feces, blood, placenta, lungs, and even breast milk [25], raising significant concerns about their toxicological effects. The primary health risks and mechanisms include:

Physical Damage: Microscopic particles can cause mechanical irritation or harm to the digestive and respiratory tracts.

Chemical Toxicity: Additives like plasticizers and flame retardants in microplastics, or harmful substances such as heavy metals and persistent organic pollutants that they adsorb from the environment, may be released into the body, leading to chemical toxicity.

Immune and Inflammatory Responses: Microplastic particles are recognized as foreign bodies by immune cells, which can trigger local or systemic inflammatory responses and oxidative stress.

Gut Microbiota Dysbiosis: Consumed microplastics may disrupt the composition and function of gut microorganisms, impacting host metabolism and immune balance.

DOI: 10.54254/2753-8818/2026.LA31718

Trans-Barrier Migration: Nano plastics, due to their extremely small size, may penetrate the intestinal or alveolar-capillary barriers, enter the circulatory system, and accumulate in organs like the liver, kidneys, and brain. They might even cross the placental barrier, posing potential risks to fetal development.

5. Conclusions and future prospects

This paper shows that microplastic pollution is now a complete path from environmental release to human exposure and health effects, with evidence growing of global dispersion and multiple risks. Microplastics enter the environment via land, ocean, and atmospheric transport and spread globally through long-range atmospheric transport and coupled soil–groundwater migration. In ecosystems, they harm organisms at all levels, from the microbes to the higher animals, causing physical injury, chemical toxicity, and acting as carrier; these effects transfer and extend along food webs and ultimately destroy ecosystem structure and function. Human exposure is most likely from diet, containing 70%–90% of the intake, with additional inhalation and dermal routes. Microplastics accumulate in multiple organs, disrupt gut microbiota, trigger respiratory oxidative stress, increase cardiovascular risk (atherosclerosis plaque formation) and accumulate in brain cells, which indicates they can cross biological barriers and produce systemic effects.

To effectively tackle the challenges of microplastic pollution, future research should concentrate on several key areas:

(1) Methodological innovation and standardization: Develop high-throughput high-precision detection methods for microplastics, nanoplastics, in different environmental samples and biological samples. These methods should reliably detect and quantify microplastics in complex matrices while maintaining reproducibility.

(2) In-depth toxicological analysis: Conduct a detailed toxicology analysis of microplastic toxicology using multi-omics, high-resolution imaging and other state-of-the-art methods. We should define the cell and molecular pathways through which microplastics cause chronic toxicity, particularly long-term lowdose exposure.

(3) Artificial intelligence (AI) risk assessment: Use AI to combine Quantitative Structure-Activity Relationship (QSAR) models with machine learning (ML) algorithms to build predictive models for microplastic toxicity. AI-based approach will streamline the costeffective screening and evaluation of environmental and human health risks posed by microplastics.

(4) Collaboration in the One Health framework: Treat microplastic pollution as a multi-domain One Health problem that affects ecosystems, animals and humans. Global repository and analytical platform should combine environmental monitoring data, animal bioaccumulation studies and clinical analyses of human samples.

In conclusion, the pollution pathway of microplastics through the “environment – organism – human body” continuum is now clear and demonstrates the urgent challenge of prevention and control. Future work should leverage cooperation between different disciplines through monitoring and intelligent prediction tools. Moreover, developing a risk assessment framework from environment to human health is also essential to provide scientific support to global ecological security and public health.

References

[1] Huang Meng, Ecology. Study on the Toxic Effects and Mechanisms of Polystyrene Microplastics on Caenorhabditis elegans [D]. Nanjing Agricultural University, 2025.

DOI: 10.54254/2753-8818/2026.LA31718

[2] Qi Bowen, Zhang Bing, Pang Fujing, et al. Influence mechanism of polystyrene nanoplastics on aerobic granular sludge [J]. China Environmental Science, 2025, 45(06): 3010-3019.
[3] Xin Jiaqi, Chen Shengxue, Li Kemao, et al. Distribution characteristics of microplastics in the main water systems of Qinghai Province [J/OL]. Journal of Hydroecology, 2025: 1-9.
[4] Zhu H Z, Duan Y T, Xian H X, et al. Research progress on the impact of micro - and nano - plastics on human respiratory system health and their toxicity mechanisms [J/OL]. Biological Chemical Engineering, 2025: 1 - 11.
[5] Na S H, Kim M J, Kim J, et al. Fate and potential risks of microplastic fibers and fragments in water and wastewater treatment processes [J]. Journal of Hazardous materials, 2024, 463: 132938.
[6] Li Caihua. Application and Practice of Ecological Environment Restoration Technology in the Treatment of Contaminated Sites [J]. Leather Manufacturing and Environmental Protection Technology, 2024, 5(14): 46-48.
[7] Zunire Tuerxun. Effects of Decabromodiphenyl Ether on Immune Function and Tumor Immune Microenvironment in Mice with Subcutaneous Transplanted U14 Cervical Cancer [D]. Xinjiang Medical University, 2023.
[8] Zhang S X, Chen A N, Chen C K, et al. Research status and trend analysis of environmental and health risk and control of persistent, mobile, and toxic chemicals [J]. Environmental Science, 2023, 44(6): 3017–3023.
[9] Sun, X. Y., Zhuang, Y., Wang, Y. B., et al. Research progress on environmental exposure to microplastics and their effects on human health [J]. Research of Environmental Sciences, 2023, 36(05): 1020-1031.
[10] Li W, Zu B, Yang Q, et al. Sources, distribution, and environmental effects of microplastics: A systematic Review [J]. RSC Advances, 2023, 13(23): 15566–15574.
[11] Feng F, Ye W, Xiang S, et al. Factors influencing the migration and distribution of microplastics in the Environment [J]. Frontiers of Environmental Science & Engineering, 2025, 19(10).
[12] Xi B, Wang B, Chen M, et al. Environmental behaviors and degradation methods of microplastics in different environmental Media [J]. Chemosphere, 2022, 299: 134354.
[13] Khu S-T, Li F, Zhao W. Microplastics in drinking water distribution systems: Occurrence, environmental behavior, and human health Concerns [J]. Environmental Pollution, 2025, 382: 126666.
[14] Guo M, Noori R, Abolfathi S. Microplastics in freshwater systems: Dynamic behaviour and transport Processes [J]. Resources, Conservation and Recycling, 2024, 205: 107578.
[15] Liu W, Liao H, Wei M, et al. Biological uptake, distribution and toxicity of micro(nano)plastics in the aquatic biota: A special emphasis on size-dependent Impacts [J]. TrAC Trends in Analytical Chemistry, 2024, 170: 117477.
[16] Kumar A, Krishan G. Microplastic Pollutants in Aquatic Ecosystems: Present and Future Challenges [J]. Water, 2023, 16(1): 102.
[17] Yu K, Chai B, Zhuo T, et al. Hydrostatic pressure drives Microbe-mediated biodegradation of microplastics in surface sediments of deep reservoirs: Novel findings from hydrostatic pressure simulation Experiments [J]. Water Research, 2023, 242: 120185.
[18] Cheng L, Li YN, Deng YJ, et al. Effects of maternal polycyclic aromatic hydrocarbon exposure during pregnancy on the physical development of newborns [J]. Journal of Environmental & Occupational Medicine, 2017, 34(05): 385-391.
[19] Hu Xueting. A Practical Report on English-Chinese Translation of *Microplastics in Human Consumer Products* (Excerpt) [D]. Southwest University of Science and Technology, 2024.
[20] Thapliyal C, Negi S, Nagarkoti S, et al. Mechanistic insight into potential toxic effects of microplastics and nanoplastics on human Health [J]. Discover Applied Sciences, 2025, 7(6).
[21] Winiarska E, Jutel M, Zemelka-Wiacek M. The potential impact of Nano- and microplastics on human health: Understanding human health Risks. [J]. Environmental Research, 2024, 251: 118535.
[22] Prata J C, Da Costa J P, Lopes I, et al. Environmental exposure to microplastics: An overview on possible human health Effects [J]. Science of The Total Environment, 2020, 702: 134455.
[23] Luo Q, Tan H, Ye M, et al. Microplastics as an emerging threat to human health: An overview of potential health Impacts [J]. Journal of Environmental Management, 2025, 387: 125915.
[24] Ji Y, Wang Y, Wang X, et al. Beyond the promise: Exploring the complex interactions of nanoparticles within biological Systems [J]. Journal of Hazardous Materials, 2024, 468: 133800.
[25] Paul I, Mondal P, Haldar D, et al. Beyond the cradle – Amidst microplastics and the ongoing peril during pregnancy and neonatal stages: A holistic Review [J]. Journal of Hazardous Materials, 2024, 469: 133963.