Environmental Research and Ecotoxicity. 2025; 4:152
doi: 10.56294/ere2025152

REVIEW

Micro and nanoplastics: a global threat to health and the environment

Micro y nanoplásticos: una amenaza global para la salud y el ambiente

Estefanía Denise Wolfenson[1], Cristina Angelica Bustos[1]

[1]Universidad Abierta Interamericana, Facultad de Medicina y Ciencias de la Salud, Carrera de Medicina. Buenos Aires, Argentina.

Cite as: Wolfenson ED, Bustos CA. Micro and nanoplastics: a global threat to health and the environment. Environmental Research and Ecotoxicity. 2025; 4:152. https://doi.org/10.56294/ere2025152

Submitted: 18-04-2024 **Revised:** 26-08-2024 **Accepted:** 11-01-2025 **Published:** 12-01-2025

Editor: Prof. Dr. William Castillo-González

ABSTRACT

Over recent decades, the mass production of plastics has significantly transformed consumption patterns and industrial processes, with environmental and health consequences. Among these, the growing presence of micro- and nanoplastics, tiny particles derived from the degradation of larger plastics or manufactured directly, stands out. These particles were detected in various ecosystems and in the human body, which generated scientific concern. The studies reviewed revealed that these pollutants acted as vectors of toxic substances, affecting biodiversity and posing a risk to human health by causing inflammation, endocrine disruptions and transgenerational effects. Despite advances in detection technologies and mitigation strategies — such as recycling, the circular economy and biodegradation — challenges persisted in the standardisation of methodologies, toxicological knowledge and regulatory development, making an interdisciplinary and coordinated approach urgent.

Keywords: Microplastics; Toxicity; Ecosystems; Health; Regulation.

RESUMEN

Durante las últimas décadas, la producción masiva de plásticos transformó significativamente los patrones de consumo y los procesos industriales, generando consecuencias ambientales y sanitarias. Entre ellas, destacó la creciente presencia de micro y nanoplásticos, partículas diminutas derivadas de la degradación de plásticos mayores o manufacturadas directamente. Estas partículas fueron detectadas en diversos ecosistemas y en el cuerpo humano, lo que generó preocupación científica. Los estudios revisados revelaron que estos contaminantes actuaron como vectores de sustancias tóxicas, afectando la biodiversidad y representando un riesgo para la salud humana, al causar inflamación, disrupciones endocrinas y efectos transgeneracionales. A pesar de los avances en tecnologías de detección y estrategias de mitigación —como el reciclaje, la economía circular y la biodegradación—, persistieron desafíos en la estandarización de metodologías, el conocimiento toxicológico y el desarrollo normativo, lo que hizo urgente un enfoque interdisciplinario y coordinado.

Palabras clave: Microplásticos; Toxicidad; Ecosistemas; Salud; Regulación.

INTRODUCTION

In recent decades, the mass production of plastics has significantly transformed consumption patterns and industrial processes worldwide. This transformation, driven by the physical and chemical properties of polymers, has contributed to economic and technological development, but has also generated serious environmental and health consequences. One of the most worrying is the growing presence of micro- and nanoplastics, tiny particles that result from the degradation or direct manufacture of plastic products. These emerging contaminants have not only been detected in various ecosystems, including the most remote on the planet, but also in the human body, raising alarm among scientists and international organizations.[1,2]

This review aims to analyze the impact of micro- and nanoplastics on both the environment and human health, highlighting their origin, exposure routes, toxic effects, detection techniques, and main mitigation strategies. Through the analysis of updated scientific literature, we aim to contribute to understanding a phenomenon whose magnitude and complexity require an interdisciplinary approach, as well as a joint commitment between governments, scientific communities, and civil society.

DEVELOPMENT

The exponential growth in the production and use of plastics has been one of the most distinctive features of modern society, with applications ranging from industry to the home. Their durability, low cost, and versatility have made them essential materials for developing various human activities.[3] However, this same durability has led to an unprecedented environmental crisis. According to Geyer et al.[4], between 1950 and 2015, more than 8,3 billion tons of plastic were produced, of which only 9% was recycled, while the rest was incinerated or dumped into the environment.

One of the main problems arising from the massive use of plastics is the generation of microplastics (MP) and nanoplastics (NP). Microplastics are defined as solid particles between 1 μm and 5 mm in size, while nanoplastics are particles smaller than one μm, even reaching nanometric ranges between 1 and 100 nm (ISO/TR 21960:2020, cited in Lehner et al.[1]). These fragments can be generated intentionally (primary microplastics) or derived from the degradation of larger plastics (secondary microplastics) through processes such as photodegradation, oxidation, hydrolytic degradation, or mechanical abrasion.[1,5]

Various studies have revealed that these pollutants are present in terrestrial, aquatic, and atmospheric ecosystems and even in remote environments such as the poles and glaciers.[2] According to studies by Plastics Europe,[6] more than 368 million tons of plastic were produced in 2019, suggesting that the volume of microplastics in the environment has also increased proportionally. This situation is exacerbated by inefficient recycling systems and inadequate waste management, especially in developing countries.[7]

Microplastics act as vectors of pollutants because they can adsorb toxic substances such as heavy metals, pesticides, and persistent organic compounds, thereby increasing their toxicity.[8,9] Once ingested by living organisms, these contaminants can enter the food chain and bioaccumulate, causing adverse effects on human and animal health.[10,11]

From a human toxicology perspective, micro- and nanoplastics can enter the body through the digestive, respiratory, or dermal routes and cause effects such as oxidative stress, chronic inflammation, endocrine disruption, neurotoxicity, and metabolic alterations.[12,13] The type of polymer, its size, shape, and the chemical additives present in its structure largely determine its level of toxicity.[14,15]

For example, bisphenol A (BPA) and phthalates, common additives in plastics, have been extensively studied for their ability to interfere with the endocrine system, affecting fertility, fetal development, and thyroid function.[16] Similarly, recent studies have documented the presence of microplastics in the human placenta, suggesting prenatal exposure that could have transgenerational implications.[17]

In the environmental sphere, microplastics affect biodiversity and alter ecological cycles. In marine environments, for example, they interfere with numerous species' feeding and reproductive behavior, from zooplankton to large fish and marine mammals.[18,19]

These emerging pollutants are detected and analyzed using techniques such as FTIR, SEM, ICP-MS, and TEM, which allow their composition, origin, and morphological characteristics to be identified.[20] However, standardization of these methodologies remains challenging.[5]

Given this situation, various mitigation strategies have been proposed, ranging from improved waste management to implementing a circular economy based on reduction, reuse, and recycling.[21] Biotechnological methods are also being developed, such as using microorganisms capable of biodegrading certain plastics.[22,23]

In terms of regulations, international organizations such as the UN, WHO, and the European Union have begun to take regulatory measures to limit the use of microplastics in consumer products and promote scientific research on their effects.[24] Although legislative progress is still in its infancy in Argentina, bills have been introduced to ban microplastics in cosmetics and improve packaging management.[25,26]

The study of micro- and nanoplastics is an emerging field that requires an interdisciplinary approach, given their ubiquitous and persistent nature and potential to generate environmental and health impacts. As Perilla-Portilla et al.[27] warn, we face an invisible threat that requires urgent attention from science, politics, and society.

CONCLUSIONS

The available scientific evidence strongly demonstrates that micro- and nanoplastics constitute a global, persistent, and expanding threat whose implications go beyond the environmental sphere to directly affect human health. Their ability to act as vectors of contaminants, their persistence in ecosystems, and their presence in human biological tissues position them as one of the main challenges of the 21st century concerning pollution.

Although advances have been made in detection technologies and mitigation strategies, gaps in knowledge regarding toxicity mechanisms, chronic exposure, and synergy with other chemicals require further research. Likewise, there is an urgent need to strengthen regulatory frameworks and public policies that reduce the production and indiscriminate use of plastics, while promoting sustainable alternatives within a circular economy framework. In this context, the approach to micro- and nanoplastics must be comprehensive, based on scientific evidence, and focused on the well-being of people and the planet.

REFERENCES

1. Lehner R, Weder C, Petri-Fink A, Rothen-Rutishauser B. Emergence of nanoplastic in the environment and possible impact on human health. Environ Sci Technol. 2019;53(4):1748–65. Disponible en: https://pubs.acs.org/doi/abs/10.1021/acs.est.8b05512

2. Perilla-Portilla FE, Quiroz Ortega JF. Microplásticos, una amenaza invisible para la salud humana y el medio ambiente. Rev Cubana Salud Pública. 2023;49(4):e18019. Disponible en: https://revsaludpublica.sld.cu/index.php/spu/article/view/18019

3. Rosado Sanz A, Rodriguez Rivas LI, Zofio Salvador V, Ferrer Caraco E, Carranza Egaña I. Microplásticos: su toxicidad y valores alerta pendientes de establecer. Eurifins Environment Testing. Julio–Agosto 2021.

4. Geyer R, Jambeck JR, Law KL. Production, use, and fate of all plastics ever made. Sci Adv. 2017;3:e1700782. Disponible en: https://www.science.org/doi/10.1126/sciadv.1700782

5. Zhao B, Rehati P, Yang Z, Cai Z, Guo C, Li Y. The potential toxicity of microplastics on human health. Sci Total Environ. 2024;912:168946. Disponible en: https://doi.org/10.1016/j.scitotenv.2023.168946

6. Ke D, Zheng J, Liu X, Xu X, Zhao L, Gu Y, et al. Occurrence of microplastics and disturbance of gut microbiota: a pilot study of preschool children in Xiamen, China. eBioMedicine. 2023;97:104828. Disponible en: https://doi.org/10.1016/j.ebiom.2023.104828

7. Ríos MF, Márquez F, Gatti M, Galván D, Bravo G, Bigatti G, et al. MICROPLÁSTICOS: MACROPROBLEMAS. Residuos plásticos en Argentina: su impacto ambiental y en el desafío de la economía. 1a ed. Ciudad Autónoma de Buenos Aires: ANCEFN; 2020. ISBN: 978-987-4111-15-9. Disponible en: https://ri.conicet.gov.ar/handle/11336/12991

8. Gaspar L, Bartman S, Coppotelli G, Ross JM. Acute Exposure to Microplastics Induced Changes in Behavior and Inflammation in Young and Old Mice. Int J Mol Sci. 2023;24:12308. Disponible en: https://doi.org/10.3390/ijms241512308

9. Hahladakis NJ, Velis CA, Weber R, Iacovidou E, Purnell P. An overview of chemical additives present in plastics: Migration, release, fate and environmental impact during their use, disposal and recycling. J Hazard Mater. 2018;344:179–99. Disponible en: https://www.sciencedirect.com/science/article/pii/S030438941730763X

10. Liu H, Xiang Y, He D, Li Y, Zhao Y, Wang S, et al. Leaching behavior of fluorescent additives from microplastics and the toxicity of leachate to Chlorella vulgaris. Sci Total Environ. 2019;678:1–9. Disponible en: https://www.sciencedirect.com/science/article/abs/pii/S0048969719319527

11. Song J, Cui S, Li P, Mingrui L. Progress on Ecotoxicological Effects of MicroPlastics Loaded Pollutants. IOP Conf Ser Earth Environ Sci. 2018;186(3):012027. Disponible en: https://iopscience.iop.org/article/10.1088/1755-1315/186/3/012027/meta

12. Hardman R. A Toxicologic Review of Quantum Dots: Toxicity Depends on Physicochemical and Environmental Factors. Environ Health Perspect. 2016;114(2):147–A126. Disponible en: https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.8284

13. Sorci G, Loiseau C. Should we worry about the accumulation of microplastics in human organs? eBioMedicine. 2022;82:104191. Disponible en: https://doi.org/10.1016/j.ebiom.2022.104191

14. Prata JC, da Costa JP, Lopes I, Duarte AC, Rocha-Santos T. Environmental exposure to microplastics: An overview on possible human health effects. Sci Total Environ. 2020;702:134455. Disponible en: https://doi.org/10.1016/j.scitotenv.2019.134455

15. Zheng H, Vidili G, Casu G, Navarese EP, Sechi LA, Chen Y. Microplastics and nanoplastics in cardiovascular disease—a narrative review with worrying links. Front Toxicol. 2024;6:1479292. doi: 10.3389/ftox.2024.1479292

16. Flaws J, Damdimopoulou P, Patisaul HB, Gore A, Raetzman L, Vandenberg LN. Plastics, EDCs & Health: A Guide for Public Interest Organizations and Policy-Makers on Endocrine Disrupting Chemicals & Plastics. Endocrine Society and IPEN; Diciembre 2020.

17. Zhu L, Zhu J, Zuo R, Xu Q, Qian Y, An L. Identification of microplastics in human placenta using laser direct infrared spectroscopy. Sci Total Environ. 2023;856:159060. Disponible en: https://www.sciencedirect.com/science/article/pii/S0048969722061599

18. Akanyange SN, Lyu X, Zhao X, Li X, Zhang Y, Crittenden JC, et al. Does microplastic really represent a threat? A review of the atmospheric contamination sources and potential impacts. Sci Total Environ. 2021;777:146020. Disponible en: https://www.sciencedirect.com/science/article/abs/pii/S0048969721010871

19. Bennett ER, Panagiotakis I. Microplastic in the Environment: Pattern and Process. Environmental Contamination Remediation and Management. Cham: Springer; 2022. ISBN: 978-3-030-78627-4. Disponible en: https://doi.org/10.1007/978-3-030-78627-4.

20. Ruíz-Santoyo V, Cruz-Mérida J, García Carvajal S, Arenas Arrocena MC. Microplásticos y nanoplásticos: una amenaza para la salud humana y el medio ambiente. Mundo Nano. 2025;18(34):1e–26e. Disponible en: https://doi.org/10.22201/ceiich.24485691e.2025.34.69832

21. Gamarra-Jiménez AI, Salazar-Sánchez MR. Microplásticos en cuerpos de agua continentales: Revisión de literatura sobre impactos y estrategias de mitigación desde la perspectiva de la ingeniería agroindustrial. BISTUA Rev FCB. 2024;22(1). Disponible en: https://doi.org/10.24054/bistua.v22i1.2901

22. Anand U, Dey S, Bontempi E, Ducoli S, Vethaak AD, Dey A, et al. Biotechnological methods to remove microplastics: a review. Environ Chem Lett. 2023;21(3):1787–810. Disponible en: https://doi.org/10.1007/s10311-022-01552-4

23. Veluru S, Ramakrishna S. Biotechnological approaches: degradation and valorization of waste plastic to promote the circular economy. Circular Economy. 2024;3(1):100077. Disponible en: https://doi.org/10.1016/j.cec.2024.100077

24. Bollaín Pastor C, Vicente Agulló D. Presencia de microplásticos en aguas y su potencial impacto en la salud pública. Rev Esp Salud Pública. 2019;93:e201908064. Disponible en: https://www.scielosp.org/article/resp/2019.v93/e201908064/

25 Marturano V, Cerruti P, Ambrogi V. Polymer additives. Phys Sci Rev. 2017;2. Disponible en: https://doi.org/10.1515/psr-2016-0130

26. Shen M, Zeng Z, Song B, Yi H, Hu T, Zhang Y, et al. Neglected microplastics pollution in global COVID-19: Disposable surgical masks. Sci Total Environ. 2021;790:148130. Disponible en: https://doi.org/10.1016/j.scitotenv.2021.148130

27. Perilla-Portilla FE, Quiroz Ortega JF. Microplásticos, una amenaza invisible para la salud humana y ambiente. Rev Cubana Salud Pública. 2023;49(4):e18019. Disponible en: https://www.researchgate.net/publication/380397868

FUNDING
None.

CONFLICT OF INTEREST
None.

AUTHOR CONTRIBUTIONS

Conceptualization: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Data curation: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Formal analysis: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Research: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Methodology: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Project management: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Resources: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Software: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Supervision: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Validation: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Visualization: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Writing – original draft: Estefanía Denise Wolfenson, Cristina Angelica Bustos.
Writing – review and editing: Estefanía Denise Wolfenson, Cristina Angelica Bustos.