World Journal of Pharmacology and Toxicology

Bhang, World J Pharmacol Toxicol 2025, 8:1

Editorial Open Access

Assessing the Toxicity of Microplastics: Advances in Detection and Risk Assessment

Bhang Don*

School of Chemistry and Biological Engineering, University of Science and Technology Beijing, China

Abstract

Microplastics (MPs) are emerging environmental pollutants with potential toxicological risks to human health and ecosystems. Their small size, diverse chemical composition, and ability to adsorb hazardous contaminants raise concerns regarding their bioavailability and toxicity. Recent advances in detection technologies, such as spectroscopic and imaging techniques, have improved the identification and quantification of MPs in biological and environmental samples. However, challenges remain in standardizing methodologies for accurate exposure assessment. Toxicity studies suggest that MPs can induce oxidative stress, inflammation, genotoxicity, endocrine disruption, and neurotoxicity, with effects varying based on particle size, shape, and chemical composition. Risk assessment frameworks are evolving to incorporate these findings, but uncertainties persist regarding chronic exposure effects and long-term health implications. This review explores the latest advancements in microplastic detection, toxicological mechanisms, and risk assessment strategies, emphasizing the need for regulatory policies and future research directions to mitigate potential hazards.

Keywords: Microplastics; Toxicity; Risk assessment; Environmental pollutants; Detection methods; Bioavailability; Oxidative stress; Inflammation

Introduction

Microplastics (MPs), defined as plastic particles smaller than 5 mm, have become a growing environmental and public health concern due to their widespread presence in air, water, soil, and the food chain. These particles originate from the breakdown of larger plastic debris (secondary microplastics) or are intentionally manufactured for industrial and commercial applications (primary microplastics), such as in cosmetics, textiles, and pharmaceuticals. Given their persistent nature and ability to adsorb harmful chemicals, MPs pose potential risks to both ecosystems and human health [1]. Human exposure to MPs occurs primarily through ingestion, inhalation, and dermal contact. Studies have detected MPs in drinking water, seafood, fruits, vegetables, and even human tissues, including the lungs, placenta, and bloodstream. While the full extent of their toxicity is still under investigation, emerging evidence suggests that MPs can induce oxidative stress, inflammation, endocrine disruption, and genotoxicity, potentially leading to chronic diseases. Additionally, their ability to act as carriers for environmental pollutants, such as heavy metals and persistent organic pollutants (POPs), further exacerbates their toxic potential [2].

Advancements in detection technologies, including spectroscopic, chromatographic, and imaging techniques, have improved the identification and quantification of MPs in biological and environmental samples. However, significant challenges remain in standardizing methodologies, assessing long-term exposure risks, and understanding their impact at the cellular and molecular levels [3]. Current risk assessment frameworks struggle to incorporate the complexity of MP toxicity, necessitating new approaches to evaluate chronic exposure effects and inform regulatory policies. This review explores the latest advancements in microplastic detection methods, toxicological mechanisms, and evolving risk assessment strategies, emphasizing the need for further research to understand their long-term health implications and develop effective mitigation strategies [4].

Discussion

The toxicity of microplastics (MPs) is a growing concern due to their persistent nature, widespread distribution, and potential health impacts on both humans and ecosystems. While significant progress has been made in understanding MP exposure pathways and toxicological effects, numerous knowledge gaps remain. This discussion explores the key findings related to mechanisms of MP toxicity, challenges in detection and risk assessment, and implications for public health and regulatory policies [5].

Mechanisms of Microplastic Toxicity

The toxicity of MPs is influenced by their size, shape, chemical composition, and surface properties, as well as their ability to interact with biological systems. Several mechanisms have been proposed for MP-induced toxicity:

Oxidative Stress and Inflammation: MPs can induce the production of reactive oxygen species (ROS), leading to oxidative stress and inflammatory responses in exposed tissues. Studies have reported increased inflammation and immune activation in organisms exposed to MPs, particularly in the lungs, gastrointestinal tract, and circulatory system [6].

Genotoxicity and DNA Damage: MPs and the chemicals they adsorb, including heavy metals and persistent organic pollutants

***Corresponding author:** Bhang Don, School of Chemistry and Biological Engineering, University of Science and Technology Beijing, China, E- mail: bhangdon@gmail.com

Received: 01-Jan-2025, Manuscript No: wjpt-25-163620, **Editor Assigned:** 03-Jan-2025, pre QC No: wjpt-25-163620 (PQ), **Reviewed:** 17-Jan-2025, QC No: wjpt-25-163620, **Revised:** 24-Jan-2025, Manuscript No: wjpt-25-163620 (R), **Published:** 30-Jan-2025, DOI: 10.4172/wjpt.1000287

Citation: Bhang D (2025) Assessing the Toxicity of Microplastics: Advances in Detection and Risk Assessment. World J Pharmacol Toxicol 8: 287.

(POPs), have been linked to DNA fragmentation, chromosomal aberrations, and epigenetic modifications, raising concerns about potential carcinogenic effects.

Endocrine Disruption: MPs can leach endocrine-disrupting chemicals (EDCs), such as bisphenols, phthalates, and dioxins, which interfere with hormonal balance [7]. These disruptions may contribute to reproductive toxicity, metabolic disorders, and developmental abnormalities.

Neurotoxicity: Emerging research suggests that MPs and their associated chemicals can cross the blood-brain barrier, leading to neuroinflammation, altered neurotransmitter function, and cognitive impairment in experimental models [8].

Challenges in Detection and Exposure Assessment

One of the major obstacles in MP research is the accurate detection and quantification of MPs in biological and environmental samples. Advanced techniques, such as Raman and Fourier-transform infrared (FTIR) spectroscopy, have improved MP identification, but challenges remain in standardizing methodologies, distinguishing MPs from other particles, and detecting nanoscale plastic fragments (nanoplastics) [9].

Implications for Public Health and Regulatory Strategies

Given the growing evidence of MP toxicity, regulatory actions and mitigation strategies are urgently needed. Strengthening plastic waste management policies to reduce MP pollution at the source. Developing international standards for MP monitoring and risk assessment. Promoting the use of biodegradable or alternative materials in consumer products. Encouraging further research on human health impacts to inform safety guidelines and exposure limits [10].

Conclusion

The potential toxicity of microplastics is an emerging global concern that requires a multidisciplinary approach involving toxicology, environmental science, and regulatory policies. While progress has been made in understanding MP-induced oxidative stress, inflammation, genotoxicity, and endocrine disruption, uncertainties remain regarding long-term exposure effects and transgenerational impacts. Future research should focus on refining detection techniques, assessing chronic exposure risks, and developing evidence-based regulations to protect human health and the environment.

References

1. Mormann F, Kreuz T, Rieke C, Andrzejak RG, Kraskovet A, et al. (2005) On the predictability of epileptic seizures. Clin Neurophysiol 116:569-587.
2. Bandarabadi M, Rasekhi J, Teixeira CA, Karami MR, Dourado A, et al. (2015) On the proper selection of preictal period for seizure prediction. Epilepsy Behav 46:158-166.
3. Valderrama M, Alvarado C, Nikolopoulos S, Martinerie J, Adam C, et al. (2012) Identifying an increased risk of epileptic seizures using a multi-feature EEG-ECG classification. Biomed Sign 7:237-244.
4. Ramgopal S, Thome-Souza S, Jackson M, Kadish NE, Fernandez IS, et al. (2014) Seizure detection, seizure prediction, and closed-loop warning systems in epilepsy. Epilepsy Behav 37:291-307.
5. Acharya UR, Vinitha Sree S, Swapna G, Martis RJ, Suri JS, et al. (2013) Automated EEG analysis of epilepsy: a review. Knowledge-Based Syst 45:147-165.
6. Vergara XC, Sevilla A, D'Souza SL, Ang YS, Schaniel C, et al. (2010) Patient-specific induced pluripotent stem-cell-derived models of LEOPARD syndrome. Nature 465: 808-812.
7. Casimiro MC, Knollmann BC, Ebert SN, Vary JC, Greene AE, et al. (2001) Targeted disruption of the Kcnq1 gene produces a mouse model of Jervell and Lange-Nielsen syndrome. Proc Natl Acad Sci USA 98: 2526-2531.
8. Cho M, Joo M, Kim K, Wook Y, Lee S (2018) Biochemical and Biophysical Research Communications the immunotherapeutic effects of recombinant Bacillus rin resistant to antimicrobial peptides on Calmette-Gu e bladder cancer cells. Biochem Biophys Res Commun
9. Palugan L, Cerea M, Cirilli M, Moutaharrik S, Maroni A, et al. (2021) Intravesical drug delivery approaches for improved therapy of urinary bladder diseases. Int J Pharm X 3
10. Faheem AM, Abdelkader DH (2020) Novel Drug Delivery Systems. Elsevier LTD 1.