



## Micro Plastic Contamination: A Comprehensive Review of Risks and Sustainable Solutions

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### ABSTRACT

Plastic particles smaller than 5 mm, known as microplastics, come from microbeads, synthetic fibres, and the decomposition of bigger plastics. Surface runoff, wastewater effluent, and air deposition carry these particles to aquatic ecosystems. Microplastics can damage aquatic species, impair feeding and reproduction, and bioaccumulate toxins. Humans may have digestive, respiratory, and reproductive difficulties from intake or inhalation. Bans on microbeads, waste management improvements, sophisticated wastewater treatment plant filtration systems, and consumer education on plastic reduction and disposal are mitigation options. The detection, quantification, and regulation of microplastics remain difficult despite these efforts.

**Keywords:** Microplastics, Ecological consequences, Sources, Health risks, Mitigation, Global challenge.

### INTRODUCTION

Microplastics are tiny plastic particles that are less than 5 millimetres and are usually not visible to the human eye. They can be classified into two major groups: primary microplastics and secondary microplastics. Microbeads in personal care items and microfibers from textiles are examples of primary microplastics, which are made to be small on purpose<sup>1,2</sup>. On the other hand, secondary microplastics are bigger plastic products

that break down into smaller pieces over time as a result of weathering and other environmental conditions<sup>3,4</sup>. According to Thompson *et al.*, (2009), plastic has become an essential part of modern life, and manufacturing is predicted to surpass 300 million tonnes by 2010. Although plastics have many advantages and the possibility for future improvements, there are worries about the accumulation of waste, the damage to wildlife caused by ingestion and entanglement, chemical leaching, and the fact that current consumption patterns are



not sustainable. Approximately 4% of the world's oil production is used to make plastics, and one-third of that is used for packaging that does not last long. This linear strategy is at odds with the decreasing availability of fossil fuels and the limited capacity for waste disposal. Solutions include reducing resources, designing for recyclability, improving recycling capabilities, using bio-based materials, reducing litter, using green chemistry, doing life-cycle studies, and improving risk assessments. Because of the urgent situation caused by the rapid rise in plastic production rates, it is necessary for the public, industry, scientists, and policymakers to work together to address these concerns<sup>5</sup>.

### MP in Water ecosystem

The widespread presence of microplastics in aquatic environments, particularly freshwater ecosystems, raises concerns about their ingestion and ecological impacts. While marine microplastics have been extensively studied since the early 2000s, research on their presence and effects

in freshwater systems remains limited. More investigations are needed to understand the extent of microplastic pollution and its consequences for freshwater organisms<sup>6</sup>. The pathways through which microplastics enter the environment are diverse. They can be directly released into wastewater<sup>7,8</sup> from products like exfoliating scrubs, and they eventually find their way into aquatic systems. Additionally, when synthetic fibers like polyester and nylon clothing are washed, they shed tiny microfibers that enter wastewater and subsequently enter water bodies. Furthermore, larger plastic items such as bottles and bags gradually break down into smaller pieces through the effects of the environment, contributing to the microplastics problem (Fig. 1). Plastic microfiber pollution from textile laundering, a major source of ocean microplastics. The review covers microfiber release during washing, wastewater treatment, environmental effects on aquatic life, and potential control measures. Solutions involve textile and appliance improvements, consumer education, and potential regulations to reduce microfiber pollution<sup>9,10</sup>.

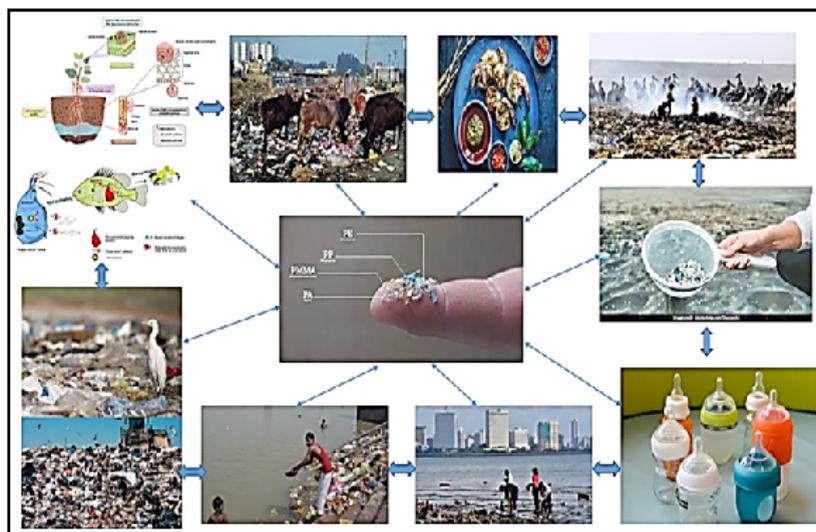


Fig. 1. Various sources of micro plastic pollution

### Breakdown of Larger Plastic Items

Rech *et al.*,<sup>11</sup> examined persistent buoyant trash, including plastics, polystyrene, and manufactured wood, along four rivers draining into the SE Pacific Ocean. Most riversides (36-82%), and coastal beaches near river mouths (67-86%), had buoyant litter. The litter mix in each river area mirrored human effects. Riverine litter was detected on both sides of river mouths on coastal beaches, decreasing with distance. High trash accumulations were often found north of the river

mouth, possibly affected by the equator ward low-level jet along the Chilean coast. The mechanisms of microplastic generation and their possible effects on the ocean environment are examined in the review by Andrady<sup>12</sup>. Plastic weathering on beaches results in surface embrittlement and microcracking, which creates microparticles that are carried into water by wind or waves. In contrast to inorganic fines, microplastics have a much higher affinity for POPs through partitioning, making them carriers of these pollutants. As a result, marine organisms

can consume microparticles containing high levels of POPs, but its bioavailability, transfer efficiency across trophic levels, and the ensuing harm to the marine ecosystem are still unknown. Aquatic species confuse microplastics for food, which can harm their digestive systems and general health. This makes ingestion a serious problem. Bioaccumulation is a troubling phenomena in which microplastics build up in organisms' tissues and become more pronounced as they ascend the food chain. Additionally, microplastics can concentrate and absorb contaminants, which makes them harmful to animals<sup>13,14</sup>.

### Bioaccumulation and Toxicity

Assessing the amounts of antimony in plastic components from different e-waste items was the goal of a 2019 study by Ayah *et al.*,<sup>15</sup>. Microwaves, computers, cell phones, and LED lights were among the items. By weight, the percentage of plastic varied from 8% to 59%. Antimony concentrations were lower in items with more plastic (1–6 mg/kg in mobile phone cases, 160–640 mg/kg in LED lamp parts), but they were noticeable in components of desktop computers and microwave ovens (25–1900 mg/kg and 830 mg/kg). According to leaching testing, these polymers may be able to be disposed of in landfills that do not handle hazardous garbage. Nano- and microplastic particles (NMPs) are ubiquitous in the environment and may have an impact on bioaccumulation by interacting with pollutants in freshwater environments. In Part II of a series, Ribeiro *et al.*,<sup>2023</sup> assess 46 studies on the effect of NMPs on the bioaccumulation of environmental pollutants in freshwater species. NMPs can either increase or decrease bioaccumulation, or they can have no impact at all<sup>16</sup>.

### Impacts on Aquatic Organisms

Microplastics (MPs) are found in a lot of marine environments because of bad plastic disposal and wastewater from factories. They are harmful to plankton, bivalves, corals, fish, seabirds, and marine mammals. This review gathers information on how common they are, how bad they are, how dangerous they are, how to clean them up, and how they are regulated. Smaller MPs (less than 5  $\mu\text{m}$ ) are especially dangerous, and popular polymers like polyethylene (PE) and polypropylene (PP) are very dangerous. Polyethylene terephthalate (PET) and polyethylene

(PE) are two of the most dangerous<sup>17</sup>. The review stresses how important it is to have effective rules and cleanup plans right away. Plastic carrier bags are a sign of bigger problems with plastic pollution<sup>18</sup>.

### Regulatory Measures and Research:

Despite growing evidence of the harmful impacts of microplastics (MPs), regulatory action remains limited and fragmented at national and global levels. Significant gaps exist in translating scientific findings into enforceable policies. Enhanced collaboration between researchers, policymakers, and stakeholders is essential for creating effective and proactive microplastics governance.

### Fragmented Regulatory Landscape

Some countries have taken steps to reduce plastic use, like banning microbeads and single-use plastics, but there isn't yet full control of microplastics as pollutants. California was one of the first states in the US to label MPs as an environmental contaminant and require tracking of MPs in drinking water. According to Coffin *et al.*,<sup>(2023)</sup>, California's work is creating new models and tools, but there are still important data gaps when it comes to exposure limits and long-term environmental effects<sup>19</sup>.

### International Efforts and Policy Trends

At the global level, organizations like the United Nations Environment Programme (UNEP) and the European Chemicals Agency (ECHA) have called for stricter controls on microplastic emissions. ECHA has proposed restricting the intentional addition of MPs in products like cosmetics and cleaning agents. In 2022, the United Nations endorsed a resolution to forge an international legally binding agreement by 2024 to end plastic pollution, including MPs and nanoplastics.

### Advances in Microplastic Detection and Identification

Recent research has made significant progress in detecting and quantifying MPs and nanoplastics. Analytical methods such as Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, and Pyrolysis-GC/MS are being refined for higher sensitivity and accuracy. A study by Schwaferts *et al.*,<sup>(2023)</sup> emphasizes the importance of standardizing these methods for inter-study comparability and regulatory acceptance<sup>20</sup>.

### Wastewater Treatment Enhancements

Recent study on microplastics has shown that they can be found in a variety of ecosystems, including aquatic animals and food products. There are increasing concerns about human health, yet scientific research has only shown that microplastics are present in some products. Although plastics can be harmful to health because of their toxicity, there is disagreement on how much microplastics are present in various meals and drinks. Because plastic is used so widely, microplastics in food and drinks are probably a small source of exposure<sup>21</sup>. This discussion has the potential to distract from the actual problem, which is the consumption, use, and disposal of plastic, resulting in its presence in our lives and environment.

### Consumer Education

Plastic pollution, especially microplastics (MPs) and nanoplastics (NPs), has become a major threat to both human health and the environment around the world. In the past few years, scientific study has come a long way, but most people still don't fully understand these pollutants. It is important to educate consumers well in order to close this information gap, encourage environmentally friendly behaviours, and back up regulatory efforts.

### Public Awareness and Behavioral Change

Educating the public and changing how people act Nanoplastics (<1  $\mu\text{m}$ ) and microplastics (<5 mm) have been found in food, water, air, and even human cells. They can cause health problems like inflammation and hormonal imbalances. The public still doesn't fully understand their sources, affects, and pathways, though. Raising awareness through clear, science-based communication is important. Educational campaigns should focus on reducing single-use plastics, encouraging sustainable alternatives, and promoting responsible disposal practices<sup>21</sup>. As a way to get students, homeowners, and vendors involved, schools, towns, and digital platforms can offer workshops, clean-up drives, and other interactive tools that can help people change their habits for good.

### Collaboration and Communication Strategies

To stop microplastic pollution, people from different fields need to work together. Scientists need to make hard results easier to understand, and policymakers, teachers, NGOs, businesses, and the media should all work together to send clear, useful messages. Sharing new information about

ongoing study, like how things break down, build up in living things, and be toxic, and standardising definitions can help fill in the gaps in our knowledge. Multi-stakeholder cooperation ensures wide public outreach and supports effective regulatory measures, making consumer education a central pillar in managing plastic pollution<sup>22</sup>.

### Review on the microplastic sources of pollution

Microplastics, which are plastic particles smaller than five millimetres, are a serious hazard to living things and ecosystems. They originate from textile fibres, personal care items, and the breakdown of bigger plastics, among other sources. Through a variety of entry points, these particles damage aquatic life by upsetting food chains, resulting in issues with ingestion, and building up in organisms<sup>23</sup>. Public awareness campaigns, wastewater treatment improvements, research projects, and laws are some of the tactics being used to address this problem.

One of the main causes of the pervasiveness of microplastics in the environment is the use of microbeads in personal care and cosmetic products (PCCPs), which is a major worldwide concern. Microbeads, primarily polyethylene, were discovered in more than 70% of PCCPs studied in the heavily populated city of Macao, China. Through wastewater treatment facilities, the region's usage of these goods is thought to contribute to the annual release of about 37 billion microbeads into the environment. Analysis of coastal sediments showed high concentrations of microplastics, mostly less than 1 mm, indicating that although PCCPs play a major role, bigger fragmentation of plastic debris may be an even more significant contributor to the issue<sup>24</sup>. When synthetic fabrics like polyester, nylon, and acrylic are washed and worn, microfibers are released. The environment may be exposed to these microfibers, which are released into wastewater.

Duis and Coors' study provides insight into the sources and patterns of deposition of microplastics, especially microfibers, on shorelines worldwide<sup>25</sup>. Microplastic concentrations in storm water flow from a suburban area close to Paris, France, were the main focus of the study<sup>26</sup>. The study used microscopy and spectroscopy to identify microfibers (MFs) and microplastics (MPs) in samples obtained from several rain events. Different patterns between MFs and MPs were noted, with median concentrations of 1.9 MFs/L and 29 MPs/L. The highest MP levels might indicate behavioural

differences because they were found prior to the peak rain flow. Similar to macroplastics at the same location, MPs had an estimated median mass concentration of 56  $\mu\text{g/L}$ . These findings provide possible directions for future research and shed light on the dynamics of microplastics in urban water systems. by Robin *et al.*, In this study, the release of microfibers from synthetic textiles during washing is investigated<sup>27</sup> and variables such fabric type and washing circumstances are examined. This study by Hartman *et al.*, contributes to a standardised method in the investigation of plastic pollution by discussing a definition and classification framework for plastic waste, including microfibers<sup>28</sup>. Although this study does not specifically address microfibers, Zubris and Richards disclose that it highlights the possible paths for synthetic fibres, such as those found in textiles, to enter the environment as indications of sludge that has been applied to land<sup>29</sup>.

De Falco *et al.*, looked into the release of microfibers during washing while taking into account the qualities of the garments<sup>30</sup>. According to the results, there was a microfiber discharge of 640,000–1,500,000 microfibers per kilogramme of cleaned cloth, or 124–308 mg. Fibre type and yarn twist were two textile characteristics that affected release patterns. Polyester-cellulose clothes released cellulosic microfibers. The bulk of shed microfibers were caught by filters with 60  $\mu\text{m}$  holes, 360–660  $\mu\text{m}$  length, and 12–16  $\mu\text{m}$  diameter. This suggests microfibers could escape wastewater treatment facilities and harm marine life. Nurdles, also known as pre-production plastic pellets, are microscopic plastic pellets used to make plastic. These pellets may be accidentally released into aquatic bodies during handling, shipping, and manufacture<sup>31</sup>. Different trace metal concentrations, sometimes higher than those in local sediments, have been found in plastic manufacture pellets collected from beaches in southwest England. Through the addition of 5  $\mu\text{g L}^{-1}$  of trace metals to 10  $\text{g L}^{-1}$  pellet suspensions in filtered seawater, the study examined the interaction of metals with virgin and beached polyethylene pellets. The results showed fast kinetics, with equilibrium partition coefficients up to about 225  $\text{mL g}^{-1}$  and reaction times less than 100 hours. Interestingly, beached pellets proved to have higher coefficients than virgin ones every time. Both the Freundlich and Langmuir equations were followed by the adsorption isotherms, which demonstrated higher adsorption capabilities for beached pellets. The potential of plastics as a

medium for metal transport in maritime environments is thus highlighted. Hidalgo *et al.*,<sup>32</sup> used neuston nets to obtain surface seawater samples, while sediment samples were mostly taken from sandy high-tide beaches. Characteristics such as type, form, degradation stage, and colour were frequently used for visual identification. Chemical composition analysis using infrared spectroscopy proved dependable, and polyethylene and polypropylene were frequently distinguished. The units of abundance for sediment and sea surface were "items per  $\text{m}^2$ " and water column were items per  $\text{m}^3$ . Two size ranges, 500  $\mu\text{m}$ –5 mm and 1–500  $\mu\text{m}$ , were reported in the majority of studies, each with unique capture techniques. Standardised methods are advised for reliable comparisons across time and space. The link between metals and plastic manufacture pellets is examined in this work by Ashton *et al.*, which also highlights possible environmental issues because of the presence of trace metals<sup>33</sup>. Law and Thompson's paper addresses the wide-ranging problem of microplastics in the oceans, including how pre-production plastic pellets may contribute to marine contamination<sup>34</sup>. Ryan *et al.*, South Africa's coastline, which has dispersed urban-industrial centres along an open beachfront, provides an instructive model for comprehending the dispersion of beach trash<sup>35</sup>. Mesodebris (2–25 mm) was sampled at 82 beaches during three studies over a 20-year period. Plastic pieces were found to be the most common type of litter, accounting for 95% of the bulk and 99% of the count. Although there were several industrial pellets, the majority of the mass was made up of stiff plastic fragments. Common influences are suggested by the interconnected patterns between industrial pellets and other polymers. Although sampling year had no effect, beach-specific characteristics were shown to correlate with mesodebris abundance throughout surveys, suggesting consistent debris levels. Higher debris densities were routinely seen in proximity to urban-industrial centres; there was no association between runoff and population density. As with macroplastic litter, the idea that mesoplastic contamination mostly originates from local land-based sources is supported by the industrial decrease of pellet size from metropolitan centres. On four sandy beaches in Mumbai, plastic waste averaged 7.49 g and 68.83 pieces per square metre. Plastic quantity varied by beach, with the south trending upward. Dadar's plastic was heavier than Aksa's. Size fractionation showed that 41.85% of the total was microplastics (1–5 mm), with microscopic particles (1–20 mm) being

the most common. Marine life is at risk of ingesting. Juhu beach has the most microplastics (55.33%), followed by Versova, Aksa, and Dadar. Interestingly, beach activities including fishing, relaxing, and religious activities influenced abundance patterns, indicating that land-based sources generate plastic contamination on beaches<sup>36</sup>. Plastic bottles, bags, and containers break down into tiny fragments when subjected to UV light, temperature fluctuations, and physical forces<sup>37</sup>. This comprehensive research by Barner *et al.*, examines weathering and plastic debris development and fragmentation in various environments<sup>38</sup>.

Across continents, microplastics have been discovered in freshwater systems, and preliminary research indicates that different creatures consume them, according to Eerkes *et al.*,<sup>39</sup>. Similarities between freshwater and marine systems in terms of transport, prevalence, detection techniques, and possible consequences are highlighted in this study, which builds on marine studies. In freshwater, there are closer point sources, and particle movement varies depending on size and dynamics. Concerning, given the significance of freshwater

resources for food and drinking, there are still questions about how they spread to land and possible health impacts. Micro plastic contamination was detected in 93% of 259 bottles examined in a study involving 11 international bottled water brands from 19 locations across 9 nations. Typically, 10.4 particles larger than 100 um were found per litre, primarily fibres and pieces (66%) in the sample. Bottle caps, which are made of polypropylene, were the main polymer (54%). There was probably plastic in smaller particles (less than 100 um). 95% of the total 325 microplastic particles per litre were found to be between 6.5 and 100 um. Processes used in bottling and packaging probably contribute to contamination<sup>40</sup>. According to Fries and Zarf, polyethylene (PE) passive samplers are often employed to test PAHs in aquatic environments due to their excellent sorption. PE, one of the principal synthetic polymers in ocean trash, may determine marine PAH exposure and dangers. Therefore, understanding the sorption mechanism is crucial<sup>41</sup>. This study examines the sorption of numerous PAHs with varied polarity onto LDPE and HDPE to better understand how material parameters affect Fickian diffusion into PE.

**Table 1: Studies on Microplastic Sources, Contamination, and Environmental Impacts**

Source of Microplastics	Type of Microplastics	Study Focus	Key Findings	References
Personal Care & Cosmetic Products (PCCPs)	Microbeads	Environmental contamination via personal care products	Over 70% of surveyed PCCPs in Macao, China, contained microbeads; potential release of 37 billion microbeads per year	24
Synthetic Textiles	Microfibers	Release of microfibers during washing and wear	Significant release of microfibers from textiles, particularly polyester; microfiber dynamics in urban runoff observed	25-27
Synthetic Textiles	Microfibers	Microfibers in wastewater treatment	Microfibers often bypass wastewater treatment systems, with potential risks for marine organisms	30
Plastic Manufacturing	Nurdles (Pre-production pellets)	Spills during plastic manufacturing and transportation	Nurdles found in marine environments, carrying trace metals; significant environmental concern due to metal adsorption	31
General Plastic Pollution	Fragmentation	Breakdown of larger plastics into microplastics	Weathering causes fragmentation of larger plastics, contributing to microplastic pollution	37-38
Freshwater Systems	Microplastics	Distribution, transport, and impacts in freshwater	Microplastics found in freshwater systems across continents; ingestion by organisms; knowledge gaps persist regarding transport, detection, and health impacts	39
Bottled Water	Microplastic contamination	Study of bottled water from various global brands	93% of 259 bottled water samples showed microplastic contamination; polypropylene was the primary polymer	40
Marine Environment	Polycyclic Aromatic Hydrocarbons (PAHs)	Sorption of PAHs to polyethylene	Study of how PAHs are adsorbed to polyethylene in aquatic environments; highlights the role of polyethylene in PAH exposure risks	41

### Ecological Impacts

Particularly in freshwater and marine environments, microplastics' extensive and detrimental ecological effects are becoming better acknowledged. Many different kinds of creatures, from microscopic plankton to giant marine mammals and fish, consume these minute particles, which are frequently smaller than 5 mm in size. Research has demonstrated that organisms may suffer physical harm, such as internal injury or obstruction of their digestive tracts, when they consume microplastics. This may result in decreased feeding efficiency, which would make it more difficult for the impacted organisms to obtain the nutrition they need. Harmful compounds like pesticides, heavy metals, and persistent organic pollutants (POPs) can also build up after consuming microplastics. These substances are frequently absorbed by the particles and go up the food chain.

Apex predators and humans who may eat seafood are at serious risk from this bioaccumulation because these toxic compounds can spread across the food chain. Recent research has highlighted the magnitude of pollution caused by microplastics in different ecosystems. Significant ingestion of microplastics by marine creatures across several trophic levels, for instance, was discovered<sup>42</sup> by Liu *et al.*, (2025), underscoring the pervasive exposure and ecological risk. The possibility that these particles contain dangerous substances and compounds that could endanger human health is being looked into by researchers<sup>43</sup>.

### Mitigation Strategies

Many techniques have been studied to reduce microplastics in the environment due to global awareness of pollution<sup>44</sup>. Among the main strategies.

### Policy and Regulation

Limiting or banning microbeads in personal hygiene products is a huge step. US, Canadian, and EU laws ban microbeads in cosmetics and cleaning products. Additionally, efforts are underway to include plastic containers and synthetic textiles in the standards. Recycling and eliminating single-use plastics are part of the European Union's plastics plan.

### Technological Advances

Wastewater treatment is essential to preventing microplastics from entering waterways. Microfiber filters for washing machines are being developed to collect microplastics from synthetic textiles during laundering. The ocean cleanup project is also studying large-scale plastic rubbish removal, including microplastics.

### Biodegradable Plastics Research

Biodegradable plastics research aims to generate materials that disintegrate faster in the environment, reducing plastic waste. Whether biodegradable polymers will develop harmful byproducts or other environmental risks is still unclear.

### Consumer Education and Behaviour Change

Educating consumers about microplastics' environmental impacts and encouraging sustainable practices like reducing single-use plastics is crucial to mitigation. Long-term change involves public knowledge and plastic product alternatives.

## CONCLUSION

This article shows the complex issues microplastic contamination poses to human health, ecosystems, and environmental sustainability worldwide. Despite advances in our knowledge of their sources, distribution, and impacts, long-term ecological and health implications including bioaccumulation and contaminant interactions remain missing. Several industries must work together to solve these issues. Tighter controls, waste management, and wastewater treatment are crucial. Public awareness initiatives and biodegradable plastics can prevent microplastic pollution. Global cooperation, standardised research, and policy-driven solutions will enable effective mitigation. Science, law, and public involvement can reduce microplastics' detrimental impacts and create a healthier, more sustainable world for future generations.

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### Conflict of Interest

There is no conflict of interest.

## REFERENCES

1. Anderson, A.G.; Grose, J.; Pahl, S.; Thompson, R.C.; Wyles, K., *J. Mar. Pollut. Bull.*, **2016**, *113*(1-2), 454–460. <https://doi.org/10.1016/j.marpolbul.2016.10.048>.
2. Aravin Prince Periyasamy.; Ali Tehrani-Bagha., *Polymer Degradation and Stability*, **2022**, *199*, 109901. <https://doi.org/10.1016/j.polyimdegradstab.2022.109901>.
3. Geyer, R.; Jambeck, J.R.; Law, K.L., *Sci. Adv.*, **2017**, *3*(7), e1700782. <https://doi.org/10.1126/sciadv.1700782>.
4. Rochman, C.; Hoh, E.; Kurobe, T., *Sci. Rep.*, **2013**, *3*, 3263. <https://doi.org/10.1038/srep03263>.
5. Thompson, R.C.; Moore, C.J.; VomSaal, F.S.; Swan, S.H. *Philos. Trans. R., Soc. B Biol. Sci.*, **2009**, *364*(1526), 2153–2166. <https://doi.org/10.1098/rstb.2009.0053>.
6. Wagner, M.; Scherer, C.; Alvarez-Muñoz, D., *Environ. Sci. Eur.*, **2014**, *26*, 12. <https://doi.org/10.1186/s12302-014-0012-7>.
7. Eerkes-Medrano, D.; Thompson, R. C.; Aldridge, D.C., *Water Res.*, **2015**, *75*, 63–82. <https://doi.org/10.1016/j.watres.2015.02.012>.
8. Dris, R.; Gasperi, J.; Mirande, C.; Mandin, C.; Guerrouache, M.; Langlois, V.; Tassin, B., *Environ. Pollut.*, **2016**, *221*, 453–458. <https://doi.org/10.1016/j.envpol.2016.12.013>.
9. Gaylarde, C.; Baptista-Neto, J.A.; da Fonseca, E.M., *Heliyon*, **2021**, *7*(5), e07105. <https://doi.org/10.1016/j.heliyon.2021.e07105>.
10. Acharya, S.; Rumi, S.S.; Hu, Y.; Abidi, N., *Text. Res. J.*, **2021**, *91*(17-18), 2136–2156. <https://doi.org/10.1177/0040517521991244>.
11. Rech, S.; Macaya-Caquilpán, V.; Pantoja, J.F.; Rivadeneira, M.M.; JofreMadariaga, D.; Thiel, M., *Mar. Pollut. Bull.*, **2014**, *82*(1-2), 66–75. <https://doi.org/10.1016/j.marpolbul.2014.03.019>.
12. Andrady, A.L., *Mar. Pollut. Bull.*, **2011**, *62*(8), 1596–1605. <https://doi.org/10.1016/j.marpolbul.2011.05.030>.
13. Cole, M.; Lindeque, P.; Halsband, C.; Galloway, T.S., *Mar. Pollut. Bull.*, **2011**, *62*(12), 2588–2597. <https://doi.org/10.1016/j.marpolbul.2011.09.025>.
14. Wright, S.L.; Kelly, F., *J. Environ. Sci. Technol.*, **2017**, *51*(12), 6634–6647. <https://doi.org/10.1021/acs.est.7b00423>.
15. Alassali, A.; Abis, M.; Fiore, S.; Kuchta, K., *J. Hazard. Mater.*, **2019**, *380*, 120874. <https://doi.org/10.1016/j.jhazmat.2019.120874>.
16. Ribeiro, F.; Pavlaki, M.D.; Loureiro, S.; Sarmiento, R.A.; Soares, A.M.V.M.; Tourinho, P.S., *Toxics*, **2023**, *11*(6), 474. <https://doi.org/10.3390/toxics11060474>.
17. dos Santos, C.R.; Drumond, G.P.; Moreira, V.R.; de Souza Santos, L.V.; Amaral, M.C.S., *Chem. Eng. J.*, **2023**, 144936. <https://doi.org/10.1016/j.cej.2023.144936>.
18. Nielsen, T. D.; Holmberg, K.; Stripple., *J. Waste Manag.*, **2019**, *87*, 428–440. <https://doi.org/10.1016/j.wasman.2019.02.025>.
19. Coffin, S., *Environ. Sci. Adv.*, **2023**, *2*(3), 356–367. <https://doi.org/10.1039/D2VA00275B>.
20. Lamichhane, G.; Acharya, A.; Marahatha, R., *Int. J. Environ. Sci. Technol.*, **2023**, *20*, 4673–4694. <https://doi.org/10.1007/s13762-022-04261-1>.
21. Rist, S.; Carney Almroth, B.; Hartmann, N.B.; Karlsson, T.M., *Sci. Total Environ.*, **2018**, *626*, 720–726. <https://doi.org/10.1016/j.scitotenv.2018.01.092>.
22. Vighi, M.; Bayo, J.; Fernandez-Piñas, F.; Gago, J.; Gómez, M.; Hernández-Borges, J.; Herrera, A.; Landaburu-Aguirre, J.; Muniategui Lorenzo, S.; Muñoz, A.-R.; Rico, A.; Romera-Castillo, C.; Viñas, L.; Rosal, R., *Reviews of Environmental Contamination and Toxicology.*, **2021**. <https://doi.org/10.5281/zenodo.4767185>.
23. Koelmans, A. A.; Redondo-Hasselerharm, P. E.; Mohamed Nor, N. H.; Kooi, M., *Environ. Sci. Technol.*, **2020**, *54*, 12307–12315.
24. Bashir, S. M.; Kimiko, S.; Mak, C.W.; Fang, J. K. H.; Gonçalves, D., *Front. Mar. Sci.*, **2021**, *8*, 683482. <https://doi.org/10.3389/fmars.2021.683482>.
25. Duis, K.; Coors, A., *Environ. Sci. Eur.*, **2016**, *28*(1), 2. <https://doi.org/10.1186/s12302-015-0069-y>.
26. Treilles, R.; Gasperi, J.; Gallard, A.; Saad, M.; Dris, R., *Environ. Pollut.*, **2021**, *25*, 117352. <https://doi.org/10.1016/j.envpol.2021.117352>.
27. Napper, I. E.; Thompson, R.C., *Mar. Pollut. Bull.*, **2016**, *112*(1–2), 39–45. <https://doi.org/10.1016/j.marpolbul.2016.09.025>.

28. Hartmann, N. B.; Hüffer, T.; Thompson, R. C.; Hassellöv, M.; Verschoor, A.; Daugaard, A.E., *Environ. Sci. Technol.*, **2019**, *53*(3), 1039–1047. <https://doi.org/10.1021/acs.est.8b05297>.
29. Zubris, K. A.; Richards, B. K., *Environ. Pollut.*, **2005**, *138*(2), 201–211. <https://doi.org/10.1016/j.envpol.2005.04.013>.
30. De Falco, F.; Di Pace, E.; Cocca, M., *Sci. Rep.*, **2019**, *9*, 6633. <https://doi.org/10.1038/s41598-019-43023-x>.
31. Holmes, L. A.; Turner, A.; Thompson, R.C., *Environ. Pollut.*, **2012**, *160*(1), 42–48. <https://doi.org/10.1016/j.envpol.2011.08.052>.
32. Hidalgo-Ruz, V.; Gutow, L.; Thompson, R.C.; Thiel, M., *Environ. Sci. Technol.*, **2012**, *46*(6), 3060–3075. <https://doi.org/10.1021/es2031505>.
33. Ashton, K.; Holmes, L.; Turner, A., *Mar. Pollut. Bull.*, **2010**, *60*(12), 2050–2055. <https://doi.org/10.1016/j.marpolbul.2010.07.014>.
34. Law, K.L.; Thompson, R.C., *Science*, **2014**, *345*(6193), 144–145. <https://doi.org/10.1126/science.1254065>.
35. Ryan, P. G.; Perold, V.; Osborne, A.; Moloney, C.L., *Environ. Pollut.*, **2018**, *238*, 1008–1016. <https://doi.org/10.1016/j.envpol.2018.02.017>.
36. Jayasiri, H.B.; Purushothaman, C. S.; Vennila, A., *Mar. Pollut. Bull.*, **2013**, *77* (1–2), 107–112. <https://doi.org/10.1016/j.marpolbul.2013.10.024>.
37. Andrady, A. L., *Marine Anthropogenic Litter; Springer.*, **2015**, 57–72. ISBN:978-3-319-16509-7.
38. Barnes, D. K.; Galgani, F.; Thompson, R. C.; Barlaz, M., *Philos. Trans. R. Soc. B: Biol. Sci.*, **2009**, *364*(1526), 1985–1998. <https://doi.org/10.1098/rstb.2008.0205>.
39. Eerkes-Medrano, D.; Thompson, R.C.; Aldridge, D.C., *Water Res.*, **2015**, *75*, 63–82. <https://doi.org/10.1016/j.watres.2015.02.012>.
40. Mason, S.A.; Welch, V.G.; Neratko., *J. Front. Chem.*, **2018**, *6*, 407. <https://doi.org/10.3389/fchem.2018.00407>.
41. Fries, E.; Zarfl, C., *Environ. Sci. Pollut. Res. Int.*, **2012**, *19*(4), 1296–1304. <https://doi.org/10.1007/s11356-011-0655-5>.
42. Liu, J.; Zheng, L., *Environ. Pollut.*, **2025**, 125700.
43. Zhu, L.; Pan, W.; Zhao, X.; Wang, F.; Wang, C.; Kang, Y.; Dong, Z.; Shao, B.; Wu, F.; An, L. *Crit. Rev. Environ. Sci. Technol.*, **2024**, *54*(24), 1875–1901.
44. Awewomom, J.; Dzeble, F.; Takyi, Y.D.; Ashie, W.B.; Ettay, E.N.Y.O.; Afua, P.E.; Sackey, L.N.A.; Opoku, F.; Akoto, O., *Discov. Environ.*, **2024**, *2*(1), 8.