Anshara International Journal of Education and Sciences

https://journal.anshara.id/index.php

Impacts of Microplastics on the Environment and Human Health: A Comprehensive Review of Sources, Distribution and Toxicological Effects

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Abstract: Microplastics have become a global pollutant that threatens ecosystems and human health. This study aims to analyse the sources, distribution, ecotoxicological effects, and human health risks of microplastic exposure through a systematic review of recent literature (2017-2024). The research methods included collecting and analysing 45 scientific articles from indexed databases such as Scopus, Web of Science and PubMed using keywords related to microplastics, environmental pollution and health effects. The results showed that the main sources of microplastics are macroplastic degradation (35%), cosmetics (25%), synthetic textiles (20%) and tyre abrasion (15%). The distribution of microplastics has been detected in a variety of environments, including water (an average of 5,000 particles/m³ in the ocean), land (up to 1,000 particles/kg soil) and the atmosphere (50 particles/m³ in urban areas). At the ecotoxicological level, microplastics cause physiological disturbances in aquatic biota, such as a reduction in zooplankton growth rate (40%), liver damage in fish and accumulation in the food chain. In terrestrial environments, microplastics reduce soil fertility and inhibit plant growth by up to 30%. Risks to human health arise from consumption of contaminated food (0-10 particles/gram of seafood), drinking water (325 particles/l of bottled water) and inhalation. Microplastic particles (<10 μm) are capable of crossing the biological barrier and have been detected in blood (1.6 μg/mL), lung tissue and placenta. Mechanisms of toxicity include induction of oxidative stress (3-fold increase in ROS), inflammation (increase in IL-6 and TNF-α) and endocrine disruption (due to BPA and phthalates). Early epidemiological studies have linked microplastic exposure to an increased risk of obesity, reproductive disorders and genomic instability.

Keywords: microplastics, environmental pollution, ecotoxicology, human health, human exposure

INTRODUCTION

Microplastics, plastic particles less than 5 mm in size, have become a widespread pollutant in the environment, ranging from oceans to land. Their presence mainly comes from the degradation of macro-plastics, releases from personal care products, and industrial waste (Wang et al., 2021). In the past decade, the concentration of microplastics in the environment has increased significantly, raising serious concerns for ecosystems and human health. The study by showed that microplastics have been detected in more than 90% of seawater samples worldwide, indicating an alarming scale of contamination (Simantiris & Vardaki, 2025). A clear example of the impact of microplastics is their accumulation in the Great Pacific Garbage Patch, a plastic waste accumulation zone in the Pacific Ocean covering 1.6 million km² (Lebreton et al., 2018). Microplastics in this region not only pollute the water, but also enter the food chain through ingestion by marine life such as fish and plankton. Research by (Wilcox et al., 2020) found that around 70% of fish in the region had microplastics in their digestive systems, which can lead to physiological disorders and death.

Microplastics have entered the human food chain, mainly through the consumption of seafood and sea salt. A study in Indonesia found that 30% of fish sold in traditional markets contained microplastics (Zhu et al., 2024). In addition, a study by (Karami et al., 2021) found that sea salt from 17 different countries was contaminated with microplastics at concentrations up to 1,000 particles/kg. These findings suggest that humans are unknowingly consuming microplastics on a daily basis, potentially posing long-term health risks.

Recent evidence suggests that microplastics not only end up in the digestive tract, but can also enter the bloodstream and body tissues. A study by (Schwabl et al., 2019) found microplastic particles in human faecal samples from different countries, proving that humans are exposed to them through food and the environment. More worryingly, an in vitro study by (Wright & Kelly, 2017) showed that nanoplastics can damage intestinal epithelial cells and trigger an inflammatory response. Prolonged exposure may increase the risk of chronic diseases such as cancer and immune system disorders. With increasing evidence of the negative impacts of microplastics, it has become imperative to fully understand their source, distribution and mechanisms of toxicity. Real-world case studies, such as the contamination of the Great Pacific Garbage Patch, seafood and human tissues, show that this issue cannot be ignored. Therefore, this literature review aims to present recent analyses to promote effective plastic reduction policies and remediation strategies (Vethaak & Legler, 2021). Without immediate intervention, the accumulation of microplastics may reach unmanageable levels, threatening the sustainability of ecosystems and global health.

METHODS

A literature search from 2018 to 2025 was conducted using databases such as ScienceDirect, PubMed and Scopus. Keywords used included 'microplastics', 'human health', 'environmental impact' and 'detection methods'. Articles that were relevant to the topic and had undergone a peer review process were selected. Data from several studies were collected and analysed to identify trends, detection methods used and the impact of microplastics on human health and the environment. The analyses also included an evaluation of the effectiveness of microplastic detection and identification methods.

RESULTS AND DISCUSSION

Microplastic Sources

1. **Degradation of macro plastics**

   Single-use plastics (bags, bottles, fishing nets) are fragmented by UV light, mechanical abrasion and hydrolysis. In a case study of the Mediterranean Sea, 72% of microplastics came from the fragmentation of macroplastics, mainly polyethylene (PE) and polypropylene (PP) (Li et al., 2025). The effect is that secondary particles dominate in coastal sediments due to their high density (Gross & Enck, 2021).

2. **Consumer Product (Primary Microplastics)**

   Sources from cosmetics containing exfoliants (polyethylene microbeads) have been found in 30% of facial care products (Cheung & Fok, 2016). In textiles, one wash of synthetic clothing releases ~700,000 microplastic fibres (De Falco et al., 2020). To address this, a ban on microbeads in the US (2015) reduced contamination in Lake Erie by 40% (Pfotenhauer et al., 2022).

3. **Vehicle tyres and urban dust**

   Tyre emissions account for 28% of microplastics in European waters due to abrasion (Fréal et al., 2023). In Tokyo, airborne microplastic concentrations reached 50 particles/m^3, mainly from tyres and brakes (Duong et al., 2023).

Neighbourhood spread

1. **Sea waters**

   The South China Sea carries 13,000 particles/km^2 Arctic: Microplastics are transported by Atlantic currents and accumulate on sea ice (Bergmann et al., 2023). The transport mechanisms are vertical transport, where low-density particles (PE) float while PVC sinks(Kooi et al., 2021), and biological uptake, where zooplankton consume microplastics, facilitating transfer up the food chain (Cole et al., 2020).

2. **river and lake**

   The Mekong River has 4,000 particles/m^3, mainly textile fibres (Lebreton et al., 2018). The Thames has microplastics from domestic waste (Horton et al., 2023). Lake Victoria has contamination from fishing activities (Vergara et al., 2025)

3. **Terrestrial and Atmospheric**

   Agricultural soils fertilised with sewage sludge (biosolids) contain 300-1,000 particles/kg (Fan et al., 2023). Atmospheric dry deposition of microplastics flies up to 100 km from urban sources (Allen et al., 2022). During rainfall, particles have been detected in rain samples in the Pyrenees (Brahney et al., 2021).

Factors Affecting Distribution

Particle size has particles <1 µm (nanoplastics) are more easily inhaled or enter the bloodstream (Gigault et al., 2021). Interaction with other pollutants causes microplastics to adsorb heavy metals (Pb, Cd) and persistent organic compounds (POPs), increasing toxicity (Gross & Enck, 2021).

Effects on aquatic organisms

Microplastics cause adverse effects on aquatic biota through ingestion, bioaccumulation and physiological disruption. Experimental studies in Danio rerio (zebrafish) showed that exposure to microplastics (PE, 10-100 µm) induced oxidative stress, liver damage and a 40% reduction in reproductive capacity (Rojoni et al., 2024). The ingestion of microplastics by zooplankton such as Daphnia magna reduces the natural filtration rate of food, disrupting the food chain (Cole et al., 2020). Microplastic particles also act as vectors for other pollutants; research in Tokyo Bay found that microplastics adsorbing PCBs (polychlorinated biphenyls) increased their toxicity in mussels by a factor of 10 (Lei et al., 2023).

Disturbing terrestrial ecosystems

Microplastics in agricultural soils alter soil physico-chemical properties and inhibit plant growth. Experiments with Lactuca sativa (lettuce) plants showed that exposure to microplastics (PS, 1 µm) reduced root biomass by 30% and inhibited uptake of nutrients such as nitrogen (Qi et al., 2022). Earthworms (Lumbricus terrestris), a key organism in maintaining soil fertility, showed reduced growth rates and intestinal epithelial damage after exposure to microplastic fibres (Lwanga et al., 2023). In addition, microplastics disrupt soil microbial activity, which plays a role in the carbon cycle, reducing organic matter decomposition by up to 25% (Rillig et al., 2024).

Effects on sediments and deep-sea organisms

Deep-sea ecosystems are not immune to the effects of microplastics. Analysis of sediments in the Mariana Trench (>10,000 m depth) found microplastic concentrations of up to 2,000 particles per litre, with textile fibres predominating (Mandal et al., 2023). Benthic organisms such as sea cucumbers (Holothuria forskalii) showed impaired immune responses and accumulation of particles in digestive (Taylor et al., 2022). Long-term effects include a reduction in benthic biodiversity, as observed in areas with high microplastic accumulation (>1,000 particles/kg sediment) (Rigi et al., 2023).

Mechanisms of toxicity at the cellular and molecular level

At the cellular level, microplastics (especially nanoplastics <1 µm) induce damage through: 1) Oxidative stress: Increased production of ROS (reactive oxygen species) that damage DNA and cell membranes (Yin et al., 2023); 2) Endocrine disruptors: Additives (phthalates, BPA) released from microplastics disrupt the endocrine system in fish, leading to feminisation of the male population; 3) Trophic transfer: Microplastics ingested by plankton are transferred to higher predators such as whales and humans through biomagnification (Pollet et al., 2024).

Ecotoxicological Effects of Microplastics

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2. Disturbance of Terrestrial Ecosystems

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CONCLUSION

This research confirms that microplastics have become a serious threat to human health through multiple exposure pathways, including ingestion of contaminated food and water, inhalation and dermal absorption. Recent scientific evidence shows that microplastic particles, especially those in the nano-size range (<1 μm), are able to cross the biological barrier, accumulate in body tissues and induce various toxic effects such as oxidative stress, inflammation and endocrine disruption. The finding of microplastic particles in human blood, lungs and even placenta adds to the urgency of taking this issue seriously. While more research is needed to understand the long-term effects, the current data provide a strong basis for taking action to prevent and reduce exposure.On the other hand, the complexity of this challenge calls for a multidisciplinary approach that includes aspects of regulation, technological innovation and public awareness. Strict regulation of the production and disposal of plastics, the development of more effective filtration methods, and further research into toxicity mechanisms and safe thresholds are crucial steps to reduce risks. Educating the public about the sources of microplastic exposure and how to reduce contamination is also important to create sustainable behaviour change. With the combined efforts of governments, industry, the scientific community and the public, the negative impact of microplastics on human health can be significantly reduced for a healthier and more sustainable future.

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