Insights in Public Health Journal

https://doi.org/10.20884/1.iphj.2025.6.2.17945

Review Article

Literatur Review: Analysis of Health Effect of Microplastic Exposure The Aquatic Environment

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ABSTRACT

Background: Microplastics are extremely small plastic particles that are now widely found in aquatic environments and have entered the human food chain. This contamination raises serious concerns, as microplastics have the potential to carry toxic chemicals and cause various health disorders. The aim of this literature review is to identify and analyze the health impacts of microplastic exposure originating from aquatic environments, with a particular focus on Indonesia. This review seeks to compile recent scientific evidence regarding the types, sources, and exposure pathways of microplastics to humans through the food chain, and to evaluate their potential effects on the digestive, hormonal, metabolic, and immune systems.

Methods: This study employed a literature review method guided by the PRISMA model. Data sources were obtained from scientific articles published between 2020 and 2025 through databases such as Google Scholar, Garuda Journal, and PubMed.

Results: Findings indicate that microplastics have been detected in fish, shellfish, shrimp, and even human feces. The dominant types include fibers, fragments, films, and foams, containing polymers such as PTFE, polycarbonate, and nylon. Reported health effects include digestive disorders, chronic inflammation, hematological disturbances (elevated leukocyte counts, decreased hemoglobin levels), and hormonal imbalances due to plastic additives acting as endocrine disruptors. Long-term exposure has been associated with damage to the liver, kidneys, and nervous system, as well as an increased risk of chronic diseases and cancer.

Conclusions: Microplastics are not merely an environmental issue but also a tangible threat to human health. Scientific evidence indicates potential disruptions to the digestive, immune, hormonal, and metabolic systems resulting from repeated exposure.

Keywords: *Aquatic ecosystems, cancer risk, human health, metabolic disorders*, *microplastics.*

INTRODUCTION

Indonesia is one of the world's most ecologically diverse countries, boasting an abundance of natural beauty. However, it continues to face unresolved challenges related to waste management, particularly plastic pollution, which remains a pervasive issue across communities. Indonesia generates approximately 6.80 million tons of plastic waste annually, with an estimated 70% of this volume being mismanaged—openly burned (48%), illegally dumped in open spaces (13%), or discharged into waterways (9%). The National Plastic Action Partnership (NPAP) estimated that around 0.62 million tons of plastic waste entered aquatic environments in 2017[1]. Plastic accounts for roughly 10% of all human-generated waste. Most plastic waste is not recycled but instead discarded indiscriminately, ultimately contaminating aquatic ecosystems. As an archipelagic nation, Indonesia comprises approximately 80% marine territory, with a coastline stretching 95,161 km—ranking second globally after Canada[2]. It is estimated that 60–80% of marine debris originates from plastic waste[3]. Plastic plays a significant role in modern life due to its affordability,

light weight, and durability. These characteristics have driven increased demand, particularly in the packaging industry, where single-use plastic products dominate. However, the accumulation of plastic waste is exacerbated by low recycling rates. Children are particularly vulnerable to microplastic exposure compared to adults. Major sources of exposure include consumption of packaged milk containing pristine microplastics, use of plastic toys, playground equipment made from plastic materials, plastic feeding bottles, and various daily food products[4]. Microplastics can contaminate drinking water, accumulate in food chains, and release toxic substances that pose risks to human health[5].

The microplastic issue reflects the ecological consequences of plastic use in daily activities. A study by Ningrum et al. (2023) revealed that microplastic concentrations peak during the rainy season, when coastal areas receive large volumes of river runoff carrying plastic particles through estuaries[6]. Plastic waste discharged into the ocean poses risks to coastal communities. The marine environment is a major source of primary microplastics—tiny plastic particles intentionally manufactured for industrial and medical purposes, such as resins and plastic beads. In contrast, secondary microplastics result from the breakdown of larger plastic debris exposed to physical, chemical, and biological processes[7]. Microplastics not only contribute to environmental pollution but also present serious threats to human and ecological health through various toxicological pathways. These particles may enter the human body via fish consumption, carrying hazardous chemicals such as phthalates and bisphenol A (BPA)[8]. Microplastic abundance in fish has been reported at 169–333 particles/kg, with dominant types including pellets (36%), fibers (29%), fragments (29%), and films (6%). The highest contamination level was found in the midstream area of Kaliwates River (333 particles/kg), likely due to activities from traditional markets and small-scale industries[9].

Multiple studies indicate that microplastic exposure can significantly impact human health, including metabolic disorders and increased cancer risk. Additionally, microplastics may impair immune system function and contribute to the development of degenerative diseases[10]. Therefore, the aim of this literature review is to identify and analyze the health impacts of microplastic exposure originating from aquatic environments, with a particular focus on Indonesia. This review seeks to compile recent scientific evidence regarding the types, sources, and exposure pathways of microplastics to humans through the food chain, and to evaluate their potential effects on the digestive, hormonal, metabolic, and immune systems

METHODS

The method employed to identify microplastics in aquatic environments and their potential health effects on humans was a literature review guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) model. The initial stage involved collecting all relevant journal articles addressing the impact or contamination of microplastics that may contribute to human health disorders. Literature searches were conducted through online databases including Google Scholar, Garuda Journal, and PubMed. The search utilized specific keywords: “Microplastic Impact,” Microplastics in Aquatic Environments,” and “Health Disorders Caused by Microplastics.” Inclusion criteria comprised articles published between 2020 and 2025, articles appearing in national or international journals, and publications written in either Indonesian or English. All articles listed within the first five pages of search results for each keyword were compiled into a worksheet. Furthermore, from the 15 types of research articles, articles that meet the inclusion criteria according to PICOS (Population, Intervention, Comparison, Outcome, Study, and Language) were selected.

Table 1. PICOS In Literatur Review

Criteria	Inclusion	Exclusion
Population	A study on the influence of microplastics on human health in the aquatic environment	Unrelated studies on the influence of microplastics on human health in the aquatic environment
Intervention	No intervention	No intervention
Comparison	No intervention	No intervention
Outcome	Contains the results of the influence of microplastics on human health, especially in the aquatic enviroment	Does not include the results of the influence of microplastics on human health, especially in the aquatic enviroment
Study	Quantitative using observational study or descriptive, labolatorium, and experimental study	In addition to quantitative research using observational study or descriptive, labolatorium, and experimental study
Year of Publication	2020 - 2025	Before 2020 - 2025
Language	Indonesian or English	Except Indonesian or English

Subsequently, screening was conducted based on exclusion criteria, which included duplicate titles, articles accessible free of charge, and titles deemed irrelevant to the research topic. All titles meeting the exclusion criteria were then reviewed independently by two separate team members to identify the health impacts of microplastic contamination in

aquatic environments. The selected articles were analyzed for risk factors by examining the research objectives, methodologies, findings, and conclusions. This analysis was conducted collaboratively by the research team. The results of the literature search and review were then organized into a table, which serves as a foundational reference for developing conceptual frameworks related to the health risks posed by microplastic pollution in aquatic ecosystems.

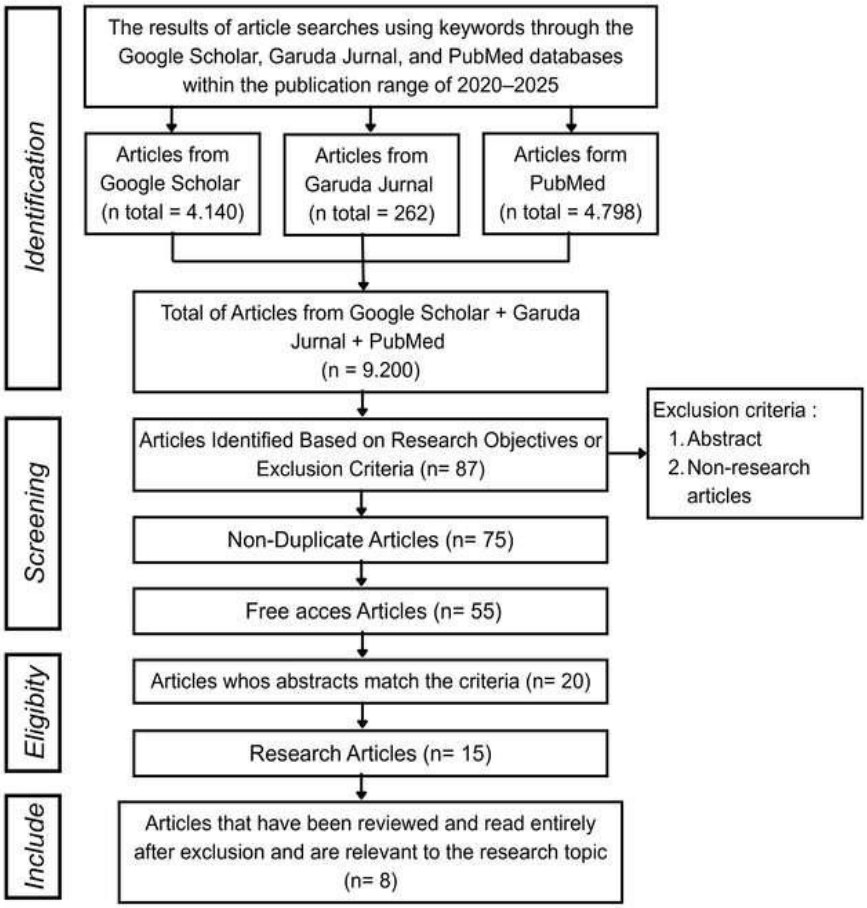

Figure 1. Data search diagram for the analysis of Health Effects of Microplastic Exposure with PRISMA

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RESULTS

Microplastics play a significant role, both directly and indirectly, in triggering various health issues in humans. The primary exposure occurs through the consumption of contaminated marine organisms such as fish, shellfish, and shrimp. Microplastic particles in the form of fibers, fragments, films, and foams have been detected in the organs of fish, blood cockles, and even in human feces, indicating a clear accumulation within the food chain. The most prominent health effects involve the digestive system, including intestinal irritation, chronic inflammation, and the accumulation of hazardous chemicals such as bisphenol A (BPA), phthalates, and heavy metals, which are known to be toxic. Studies on milkfish have revealed hematological disorders, characterized by elevated leukocyte counts and reduced hemoglobin levels, reflecting an excessive immune response and anemia. Similar mechanisms are presumed to occur in humans. Furthermore, microplastic exposure is associated with endocrine disruption, as plastic additives can act as hormone disruptors, increasing the risk of infertility, hormonal imbalances, and cancer. Several studies have also highlighted potential metabolic and degenerative impacts, including damage to the liver, kidneys,

and nervous

system, as well as the induction of oxidative stress and genetic mutations. The detection of microplastics in human feces reinforces evidence of systemic exposure, which may contribute to chronic diseases such as cardiovascular and respiratory disorders, colorectal and lung cancers.

Table 1. Findings from the Literature Review on the Health Impacts of Microplastics on Humans.

No	Title, Author and Year of Publication	Research Purpose	Research Method and Design	Research Results
1.	**Title:** Identification of Microplastic Contamination in Various Commercial Shrimp Pastes[11] **Author:** Dhanang Puspita, Pulung Nugroho, Elisabeth Nadia Kurnia Sena **Year of Publication:** 2023	Analyzing Microplastic Content in Edible Fish Organs Collected from Rawa Pening.	This study employs a quantitative descriptive approach, with research stages including microplastic isolation and microplastic analysis using Fourier Transform Infrared Spectroscopy (FTIR).	Microplastics identified in the organs of edible fish from the Rawa Pening waters were found in the form of fragments, fibers, films, and foams. The most commonly detected microplastics were transparent or clear in appearance. The types of microplastics discovered included Polytetrafluoroethylene (PTFE), Polycarbonate, Polymethyl Methacrylate (PMMA), and Polyamides (Nylon).
2.	**Title:** Plastic Waste as a Threat to the Environment[12] **Author:** Nizar Arvila Putra, Nadia Ardyta Zahranii., *et al* **Year of Publication:** 2025	This study aims to examine and analyze the threats posed by plastic waste to the environment, public health, and socio-economic aspects. Additionally, it seeks to review government regulations and policies on reducing single-use plastics, while emphasizing the crucial role of individuals and communities in preventing plastic pollution.	This approach is descriptive-analytical in nature, aiming to illustrate the condition of plastic waste issues from legal and environmental perspectives, and then interpret them to draw conclusions. The analysis is conducted using a normative qualitative method.	This study emphasizes that plastic pollution not only causes ecosystem damage but also poses serious consequences for human health. Microplastics can be ingested by humans through the consumption of fish or other seafood. This may lead to digestive disorders, organ damage, and the accumulation of harmful chemicals in the body. Additionally, microplastic particles that seep into soil and groundwater risk contaminating water sources used in daily life. This condition is hazardous because microplastics may contain heavy metals and toxic additives (such as phthalates and BPA) that act as endocrine disruptors, capable of interfering with the hormonal system. As a result, the risk of diseases such as hormonal disorders, infertility, and cancer increases.

3.	**Title:** Identification of the Presence and Types of Microplastics in Blood Clams (Anadara granosa) in the Waters of Tanjung Tiram, Ambon Bay[13] **Author:** Novianty C. Tuhumury, Agustina Ritonga. **Year of Publication:** 2020	The purpose of this study was to identify the presence and types of microplastics in cockles blood clams (Anadara granosa) in Tanjung Tiram, Ambon Bay waters.	The research method used field observations and laboratory analysis.	The results showed that in cockles, fiber was found as much as 360 particles and 61 particles of fragments. The presence of microplastics that have been consumed by cockle will be harmful marine biota as well as humans who consume the cockles. Plastics that contain harmful chemicals will be absorbed into the body of cockles. Based on the results of the study, it can be concluded that microplastics have been found and consumed by cockles.
4.	**Title:** Identification of Microplastics in Human Feces[14] **Author:** Eka Chlara Budiarti **Year of Publication:** 2021	Examining the presence of microplastics in human feces.	This study was conducted from January 2020 to February 2021 at the ECOTON Laboratory in Gresik, East Java. Fecal samples were collected from 102 respondents, with each sample consisting of 10 grams of feces. The collected samples were labeled individually on each container. Sample preparation involved the use of 20 ml of a 3:1 mixture of H_2SO_4 and H_2O_2, followed by flotation using 1% NaCl solution, and identification was carried out using a stereo microscope.	The results showed that all fecal samples tested positive for microplastic content, with a median concentration of 17.5 particles per 10 grams. Four types of microplastics were identified, with fibers being the most prevalent at 36%. Additionally, 38 polymer types were detected, with ethylene vinyl alcohol (EVOH) being the most dominant at 19%. The presence of various microplastics in human feces indicates unintentional ingestion, likely originating from contaminated food sources and environmental exposure.
5.	**Title:** Study on Microplastic Contamination and Its Effects on the Blood Profile of Milkfish (Chanos chanos) in the Northern Waters of East Java[15] **Author:** Uun Yanuhar, Andik Isdianto., *et al* **Year of Publication:** 2025	Examining the effects of microplastic contamination on the blood profile of milkfish (Chanos chanos) in the northern coastal waters of East Java.	Microplastic analysis in fish tissue was conducted using microscopic and spectroscopic methods, while blood profile analysis included the examination of hematological parameters such as erythrocyte count, leukocyte count, hemoglobin levels, and	The research findings indicate the accumulation of microplastics in the tissues of milkfish (Chanos chanos) across all sampling locations, with the highest concentrations observed in areas characterized by industrial activity and dense residential settlements. The impact of microplastics on the blood profile of the fish is evident through a significant

			hematocrit values.	increase in leukocyte count and a marked decrease in hemoglobin levels in specimens exposed to high microplastic concentrations. Microplastic contamination may adversely affect the hematological system of milkfish, with implications for ecosystem health and food safety for humans.
6.	**Title:** Environmental Health Risk Analysis of Microplastic Content in Mussels Consumed by Communities in the Waters of North Galesong[16] **Author:** Firda Aulia, Alfina Bharuddin, Abdul Gafur **Year of Publication:** 2024	This research aims to determine environmental health risks due to microplastic content in mussels (Pilsbryoconcha exilis) in North Galesong waters in 2024.	The type of research used is descriptive observational with an Environmental Health Risk Analysis (ARKL) approach by measuring risk factors at different times.	This study showed that all samples of mussel shells examined were positive for containing microplastics. The average concentration of microplastic abundance in mussels is 0.245 grams. Based on the Environmental Health Risk Analysis (ARKL), the intake of people who consume mussel shells, both real-time and lifetime, is still below the risk value of RQ<1.
7.	**Title:** Analysis of Microplastic Types and Abundance as well as Heavy Metal Pollution in the Upper Reaches of the Bengawan Solo River[17] **Author:** Muhammad Yusron, Muhammad Asroul Jaza' **Year of Publication:** 2021	The objective of this study is to assess the condition and quality of the Bengawan Solo River water and to determine the abundance of microplastics within its water body.	The microplastic research method consists of sampling and laboratory analysis. Sampling was carried out using a dry method, by scooping 100 liters of water with a plankton net, followed by filtration using T165 gauze cloth. Laboratory analysis involved sieving, digestion through the destruction of water samples using a solution mixture of H_2SO_4 and H_2O_2 at concentrations of 30% each (in a 3:1 ratio), separation via centrifugation at 3000 rpm for 15 minutes, and filtration and observation using a stereo microscope connected to a DX230 camera with a 1:40 scale.	The findings revealed the presence of microplastics in the form of fibers, fragments, and films, with an overall abundance of 51 particles per 100 liters of water. The highest concentration of microplastics was recorded at the Sukoharjo border section of the river, reaching 12 particles per 100 liters. Additional findings indicated that the Bengawan Solo River at the Samin tributary is contaminated with heavy metals such as chromium, cadmium, and lead, as well as hazardous chemical compounds including chlorine and nitrites. The level of heavy metal pollution suggests that the water quality of the Bengawan Solo River does not meet Class 3 water quality standards. Therefore, it is not safe for consumption, and may be harmful to the body.

8.	**Title:** Identification of Microplastic Contamination In Freshwater Organism Comsumption From Rawa Pening, Central Java **Author:** Dhanang Puspita, Pulung Nugroho, Rio Asysam Faisal **Year of Publication:** 2022	The purpose of this study was to identify microplastic contamination in freshwater organism in Rawa Pening.	The research method used descriptive quantitative, where samples are taken from the swamp then analyzed for their microplastic content by flotation technique and observations are made with a microscope at 40× magnification.	The results of the study showed that the water and mud from the swamp contained microplastics as well as the organism. The source of microplastics is thought to be from waste carried by 9 rivers and into the swamp of Rawa Pening

DISCUSSION

The use of plastic in daily life has become a serious environmental concern, particularly due to the persistence of plastic waste that is difficult to degrade and has polluted aquatic ecosystems. Research has shown that microplastics—extremely small plastic particles—have been found in various aquatic organisms such as fish, blood clams, and shrimp. Common types of microplastics include fibers, fragments, films, and foams, composed of polymers such as PTFE, polycarbonate, and nylon. The primary route of human exposure occurs through the consumption of contaminated seafood, indicating that microplastics have entered the food chain and pose potential risks to human health.

The health effects caused by microplastics are diverse, particularly affecting the digestive and hematological systems. Microplastics can lead to intestinal irritation, chronic inflammation, and impaired nutrient absorption. A study on milkfish (Chanos chanos) revealed an increase in leukocyte count and a decrease in hemoglobin levels, indicating an excessive immune response and anemia. The presence of microplastics in human feces further supports evidence that these particles have entered and interacted with the human digestive system, either through contaminated food or water (Hoang, 2025). Analysis of commercial seafood products has shown high levels of contamination, with an average of 6.8 microplastic particles per gram detected in shrimp paste samples (Puspita Talita, 2024). Such findings illustrate the infiltration of microplastics into food sources. The presence of microplastics in fish and shellfish may compromise the quality of seafood products for consumers (Lutfi, 2023), underscoring that microplastic pollution is not solely an ecological issue but also a direct exposure pathway to humans through food and water[11].

The primary route of microplastic exposure in humans is through the consumption of contaminated food and beverages. According to Hoang et al. (2025), microplastics enter the human body mainly via the food chain—for instance, through fish or shrimp that ingest microplastic particles, which are then consumed by humans either directly or indirectly. Once inhaled or ingested, these particles may trigger toxicological responses in the body. Studies have shown that microplastic exposure can lead to oxidative stress, chronic inflammation, and cellular damage, impairing the function of organs such as the liver, kidneys, nervous system, and reproductive system[18]. Consequently, the risk of metabolic disorders and degenerative diseases increases. Findings by Craigie et al. (2024) specifically suggest that microplastic exposure may damage digestive, reproductive, and respiratory health, and is associated with colorectal and pulmonary cancers[19]. Additionally, microplastics act as carriers for toxic plastic additives with carcinogenic properties, further elevating long-term health risks[20].

Recent studies have demonstrated a correlation between microplastic exposure and increased risk of chronic diseases in humans. Research by Deng et al. (2025) reported that microplastics serve as vectors for toxic compounds—including polycyclic aromatic hydrocarbons (PAHs), heavy metals, and plasticizers—that can induce genetic mutations and abnormal cell proliferation, contributing to tumor formation[21]. Aulia et al. (2023) similarly found that microplastics may disrupt metabolic processes, impair organ function (liver and kidneys), and increase the risk of cancer and immune system suppression[22]. In addition, microplastics carry hazardous chemicals such as bisphenol A (BPA) and phthalates, which act as endocrine disruptors. Their effects include hormonal imbalances, reduced fertility, and an increased risk of cancer. Long-term exposure to microplastics has also been associated with damage to vital organs such as the liver, kidneys, and nervous system, as well as elevated oxidative stress and genetic mutations that may trigger degenerative diseases and cancer. Several studies have shown that microplastics can induce chronic inflammation in the respiratory and digestive tracts and impair immune system function[23].

These findings indicate that microplastics are not merely an environmental issue, but also a tangible threat to human health. Therefore, it is essential to strengthen regulations on plastic waste management and promote public education about the dangers of single-use plastics. The development of environmentally friendly alternatives and further research into the toxicological mechanisms of microplastics are crucial to support more effective and sustainable public health policies. This literature review is limited by several factors that may influence the comprehensiveness and depth of the findings. First, the majority of the reviewed studies are descriptive in nature, focusing primarily on the identification and presence of

microplastics in aquatic environments and organisms, without further investigation into the biological mechanisms or causal relationships with specific human diseases. As a result, the ability to generalize the health impacts of microplastic exposure remains constrained. Second, the review relies on secondary data from previously published articles, which may vary in methodological rigor, sample size, and analytical techniques. Differences in study design and geographic focus could affect the consistency and comparability of results.

CONCLUSIONS

Research findings indicate that microplastics have been detected at nearly all levels of the aquatic food chain, ranging from fish and shellfish to shrimp, and ultimately found in human feces. This confirms that the primary route of microplastic exposure is through the consumption of contaminated food and beverages. Microplastics can cause disturbances in the digestive system, including irritation, chronic inflammation, and alterations in gut microbiota composition. Long-term exposure may impair nutrient absorption and increase the risk of metabolic disorders.

Several studies have reported hematological disruptions, such as elevated leukocyte counts as an immune response to biological stress, and reduced hemoglobin levels associated with anemia. These mechanisms suggest that microplastics may trigger excessive immune responses while simultaneously diminishing the body's oxygen transport capacity.

Microplastics also carry hazardous chemicals, including heavy metals, phthalates, and bisphenol A, which can act as endocrine disruptors. These effects are linked to hormonal imbalances, reduced fertility, growth abnormalities, and an increased risk of hormone-related cancers. Chronic exposure to microplastics is associated with damage to vital organs, particularly the liver, kidneys, lungs, and nervous system. Reported mechanisms include oxidative stress, accumulation of toxic substances, and cellular damage, ultimately heightening vulnerability to degenerative diseases.

There is strong evidence that microplastics contribute to chronic illnesses and cancer. Several studies have linked microplastic exposure to colorectal and lung cancer, as these particles can accumulate in tissues, induce genetic mutations, and carry carcinogens that accelerate tumorigenesis. These findings underscore that microplastics are not merely an environmental concern, but a tangible public health threat with the potential to affect multiple human physiological systems over the long term.

ACKNOWLEDGMENTS

A recommended strategy is to reduce the use of single-use plastics in daily life. This approach is highly feasible and can begin at the individual level, for example, by carrying reusable water bottles, using cloth shopping bags, and opting for non-plastic food containers. These small habits, when adopted collectively, can significantly reduce plastic waste production, which has the potential to degrade into microplastics and enter the food chain.

On the other hand, a notable limitation in the reviewed studies is that most remain descriptive in nature, primarily focusing on the identification of microplastic presence without further investigation into biological mechanisms or causal relationships with specific human diseases. Therefore, future research is encouraged to explore toxicological and epidemiological aspects more deeply, such as laboratory-based assessments of microplastic effects on cells and organs, as well as long-term population studies evaluating the association between exposure and chronic diseases. Addressing these gaps will strengthen the scientific foundation for public health policy and support the development of effective mitigation strategies.

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