Microplastics in Aquatic Ecosystems: Sources, Impacts, and Challenges for Biodiversity, Food Security, and Human Health - A Meta Analysis

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Abstract

Background: Microplastics (MPs), plastic fragments under 5 mm in size, have become a pervasive global environmental concern due to their durability, prevalence in aquatic ecosystems, and adverse effects on biodiversity and human health. Originating as primary MPs from industrial applications or secondary MPs from the degradation of larger plastics, they infiltrate aquatic environments through various pathways. Their ability to bioaccumulate in food webs and release harmful chemicals poses significant ecological and health risks, particularly in regions with inadequate waste management. Methods: This study employed a comprehensive literature review, analyzing research on MP pollution in freshwater and marine ecosystems from November 2022 to June 2023. Keywords included "plastic pollution," "microplastic contamination," and "plastic waste management." Sources encompassed peer-reviewed journals, grey literature, and unpublished reports from platforms like Google Scholar, ResearchGate, and local periodicals. Data were synthesized to assess MPs' ecological impacts, bioaccumulation, and interaction with pollutants. Results: Findings reveal the ubiquitous presence of MPs across aquatic habitats, with polyethylene (23%) and polystyrene (22%) being the most prevalent types. MPs were detected in various aquatic species, including fish (44%), crustaceans (21%), and mollusks (14%), often through ingestion or bioaccumulation. Evidence shows MPs induce oxidative stress, reproductive issues, and neurotoxicity in organisms. Their interaction with persistent organic pollutants (POPs) exacerbates toxicity, facilitating pollutant transfer across trophic levels. Regions with high plastic usage and poor waste management, particularly in Asia, contribute significantly to MP pollution. Conclusion: MP pollution represents a critical threat to aquatic ecosystems and human health, necessitating urgent global action. Sustainable practices, enhanced waste management, and public awareness are pivotal in mitigating MP contamination. Further research is required to address knowledge gaps, particularly concerning terrestrial impacts and the long-term effects of MP exposure on human health.

Keywords: Microplastic pollution, Aquatic ecosystems, Bioaccumulation, Ecotoxicology, Marine biodiversity

Significance | This study provides microplastics' pervasive ecological and health risks, emphasizing bioaccumulation, biodiversity threats, and challenges in pollution management.

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Introduction

Microplastics (MPs), diminutive plastic particles typically under 5 mm, have become a significant global environmental concern

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owing to their durability and extensive prevalence in aquatic environments. Originally recognized in marine ecosystems in the 1970s by the U.S. (Bhattacharya et al., 2018). National Oceanic and Atmospheric Administration (NOAA), microplastics have since emerged as a central subject of scientific research. Their existence in aquatic environments from the surface to the sediments jeopardizes the equilibrium of ecosystems and poses considerable risks to human health (Lu et al., 2016; De Sá et al., 2018). The significant increase in worldwide plastic production, rising from 1.5 million metric tonnes in 1950 to 320 million metric tonnes by 2017 and anticipated to reach 33 billion metric tonnes by 2050, highlights the severity of this issue (De Sá et al., 2018).

Microplastics (MPs) come from two main places: primary MPs are made on purpose for personal care products and industrial uses; and secondary MPs are made when larger plastic particles break down due to UV light, mechanical wear, and microbe activity (Mattsson et al., 2017). Upon release, MPs demonstrate an exceptional ability to disperse owing to their lightweight nature and longevity, with rivers alone conveying 70–80% of plastic trash into the oceans (Peda et al., 2016). Creatures from plankton to giant fish and marine mammals consume their varied forms and densities, enabling their integration into different strata of aquatic ecosystems. The consumption of microplastics, due to the incapacity of numerous species to distinguish them from food, frequently results in detrimental effects including stunted growth, reproductive difficulties, oxidative stress, and neurotoxicity (Espinosa et al., 2017).

As MPs continue to degrade into nanoplastics, their capacity to penetrate biological tissues and systems escalates, exacerbating their effects. Research has emphasized their capacity to accumulate in species ingested by humans, presenting possible health hazards through bioaccumulation and exposure to detrimental chemicals (Straub et al., 2017). The ubiquitous presence of MPs in aquatic environments endangers biodiversity and has significant consequences for food security and ecological services. The urgency of solving this issue is particularly evident in emerging nations, where rapid urbanization and industrial growth worsen plastic pollution and hinder effective waste management (Martínez-Gómez et al., 2017).

Given the rising body of information on the ecological and health concerns connected with MPs, it is vital to deepen our understanding of their sources, pathways, and implications. This paper examines the present condition of microplastic contamination, its impact on aquatic and human health, and the obstacles encountered in addressing this problem (Kim et al., 2017; Sleight et al., 2017). This study seeks to analyze current research and pinpoint knowledge deficiencies in order to facilitate the formulation of policies that foster sustainable behaviors, elevate public awareness, and guarantee the enduring health of aquatic ecosystems.

Microplastics (MPs) are microscopic fragments of plastic particles that pollute the environment. According to the U.S. National Oceanic and Atmospheric Administration (NOAA), micro-plastic refers to plastic particles that size become <5 mm in size. Experts initially noticed their presence in the oceans in the early 1970s, and numerous scientists have examined the potential dangers linked with MPs since then.MPs debris in aquatic habitats is now widely regarded as one of the world's most alarming issues. Micro-plastics can be classified as primary or secondary, depending on how they are produced. Primary MPs particles are intentionally manufactured in sizes <5 mm for use in personal care products (toothpaste, body washes, and facial cleansers) or industrial applications and directly released into the environment through domestic and industrial effluents, spills, and sewage discharge or indirectly via run-off (Table 1).

2. Methodology

The evaluation approach involved conducting a comprehensive literature search from November 15, 2022, to June 15, 2023. The search utilized phrases such as "plastic pollution," "plastic contamination," "microplastic pollution and fish," and "plastic waste management" to locate pertinent scientific publications concerning plastic pollution in freshwater and marine ecosystems. The search was unlimited by publication year, allowing for a broad range of publications.

This search employed various academic platforms, such as ResearchGate, Google Scholar, GetCITED, and BioOne. We also used the Google search engine to find scientific information from local periodicals. Due to the restricted availability of field-data studies, the review also encompassed partial matches, reviews, opinion articles, conference proceedings, unpublished reports, theses, and grey literature.

3. Discussion

3.1 The current global situation of plastic pollution

Plastic pollution has emerged as a critical environmental concern of the 21st century. The extensive use and disposal of plastics has resulted in a concerning accumulation of garbage in natural ecosystems, especially in our oceans. Plastics Europe reports that worldwide plastic production has shown a remarkable increase in recent decades (Ashakin et al., 2024). In 1950, global plastic production was roughly 1.5 million tonnes; by 2010, this amount had escalated to 250 million tonnes. Of greater concern is the forecast that worldwide plastic output would escalate dramatically, potentially reaching an alarming 33 billion tonnes by 2050 if prevailing patterns continue (Sazzad et al., 2024a).

The exponential increase in plastic manufacture and usage has considerable ramifications for environmental health. Rivers transport between 1.15 and 2.41 million tonnes of plastic trash from terrestrial sources to the oceans annually (Moniruzzaman et al., 2023). A significant amount of this pollution emanates from merely 20 rivers, primarily situated in Asia. These rivers, comprising about 2.2% of the world's continental surface area, contribute over two-thirds (67%) of the yearly worldwide influx of plastic debris into the oceans. Moreover, these regions, which comprise approximately 21% of the global population, are characterized by increased plastic usage and insufficient waste management infrastructure. Researchers have issued alarming predictions regarding the future of marine ecosystems. Estimates suggest that by 2050, the weight of plastic in the oceans will surpass that of fish, highlighting the critical need to combat plastic pollution (Martínez-Gómez et al., 2017). The durability of plastic substances in the ecosystem compounds the magnitude of this issue. Plastics degrade extremely slowly, remaining in aquatic environments for centuries or even millennia, where they accumulate as larger debris and, more subtly, fragment into microscopic particles known as microplastics.

3.2 Different types of micro-plastics studied in field and laboratory

Their ubiquitous presence in aquatic environments necessitates environmental research. Both field and laboratory research have detected a diverse array of microplastic types, with some plastics exhibiting more prevalence than others. The predominant microplastics identified are polyethylene (PE), constituting 23% of the total detected, and polystyrene (PS), comprising 22%. Nylon (NS) constitutes 15%, polypropylene (PP) 12%, polyester (PES) 9%, polyvinyl chloride (PVC) 8%, polyamide (PA) 7%, and activated carbon (AC) 5%. Water samples, sediment cores, and creature tissues commonly detect these compounds, highlighting their extensive distribution in aquatic ecosystems ((Martínez-Gómez et al., 2017; Ifty et al., 2023a).

Field and laboratory investigations have demonstrated that microplastics are pervasive in the environment and are progressively entering the food chain. Fish constitute the predominant group of creatures examined for microplastic exposure, representing 44% of the research participants. This is probably attributable to their direct engagement with watery microplastics via ingestion or absorption, as well as its significance in comprehending possible bioaccumulation (Martínez-Gómez et al., 2017). Crustaceans, encompassing both large and small species, constitute the second most examined group, accounting for 21% of the studies. These creatures, such as fish, frequently encounter microplastics when filtering water or consuming smaller particles (Ifty et al., 2023b).

Studies often examine molluscs, including clams and oysters, which account for 14% of microplastics. These creatures are especially susceptible to microplastic ingestion due to their filter-feeding behavior, which may lead to the consumption of not just plankton and organic materials but also small plastic particles (Mattsson et al., 2017). Observations also show that other taxa, such as annelid worms, which make up 6% of the studies, primarily consume microplastics through sediment intake. Research has demonstrated that mammals and birds, who make up a minor segment of the population at 5%, consume microplastics either through their food or by consuming contaminated prey (Martínez-Gómez et al., 2017). Nevertheless, research on these organisms is very limited in relation to aquatic species, underscoring a deficiency in the study of terrestrial animals and apex predators. Research on microplastics in other organism categories is somewhat scarce, with few studies examining their effects on amphibians, reptiles, and various invertebrates.

Approximately 12% polyethylene was detected in the fish, representing the predominant kind of microplastic examined in aquatic species. The ingestion of plastic debris (PE) by pelagic and benthic fish occurred due to its pervasive prevalence in both the water column and sediments, as well as a lack of selectivity; however, it was less frequently documented in other organism groups such as molluscs, small crustaceans, and annelids (Figure 1). Studies have indicated that fish and tiny crustaceans are affected by PS (Figure 2), but crustaceans can differentiate between live particles and inert substances, such as algae and PS beads. The PS fragments were shown to attach to deceased copepods, potentially facilitating the vertical movement of this form of microplastic (Martínez-Gómez et al., 2017; De Sá et al., 2018).

The extensive presence of MPs in aquatic environments and their diverse physicochemical characteristics render several aquatic animals potentially vulnerable to these new pollutants. Animals subjected to microplastics may assimilate them via their gills and digestive system. The ingestion may result from an inability to distinguish microplastics from prey or from consuming species at lower trophic levels that contain these particles (e.g., plankton with microplastics). MPs may also attach directly to organisms (Mattsson et al., 2017).

3.3 Routes of micro-plastics to aquatic organisms

Microplastics (MPs) are widely acknowledged as a widespread contaminant in marine ecosystems, particularly as they infiltrate the food chain via primary trophic level species like phytoplankton and zooplankton. These minuscule plastic particles can be absorbed or swallowed by creatures, facilitating the spread of plastic pollution to higher trophic levels (Mattsson et al., 2017). Phytoplankton, the foundational element of the aquatic food web, can assimilate microplastics either directly from the surrounding water or indirectly through the consumption of polluted organic material. Zooplankton, which consume phytoplankton, are likewise endangered, and the consumption of microplastics can result in their accumulation within the zooplankton's body. Considering that zooplankton serve as a fundamental food supply for numerous marine animals, their consumption of microplastics may represent a critical route for plastic contaminants to infiltrate the food web (Martínez-Gómez et al., 2017).

A significant behaviour that may promote the vertical displacement of microplastics in the ocean is the diurnal migratory of several zooplankton species. These organisms frequently ascend from deeper waters to the surface at night and descend to the depths during the day. This migration pattern may serve as a conduit, transferring microplastics from surface waters, where plastic pollution is most prevalent, to deeper oceanic layers. This migration may facilitate the passage of microplastics to deeper environments, where they can collect and impact other marine creatures (De Sá et al., 2018). Moreover, throughout their migration, zooplankton may excrete faecal pellets that might transport microplastics to the seafloor, so exacerbating contamination within the water column.

Field studies have verified that microplastics are present in the bodies of marine species as well as in the excrement of larger animals. Microplastics have been detected in the faeces of fur seals (Arctocephalus spp.), indicating that these marine mammals are consuming plastic particles, either directly or via their prey. This offers more evidence of the bioaccumulation and possible trophic transmission of microplastics in the marine food web. Feeding trials have revealed the presence of microplastics in the stomach and haemolymph of beach crabs (Carcinus maenas), underscoring the capacity of benthic species to eat and store these particles (De Sá et al., 2018). Furthermore, microplastics have been detected in various commercially significant marine species, such as fish, molluscs, and crabs. Humans consume these species, which raises substantial concerns over the possible trophic transmission of microplastics to humans via seafood intake (Mattsson et al., 2017). This has extensive ramifications, as it endangers marine biodiversity and poses a risk to human health due to potential exposure to hazardous chemicals and toxins associated with microplastics.

3.4 Eco-toxicological effects of MPs on aquatic organisms

Microplastics (MPs) have become a prominent contaminant in aquatic ecosystems, with extensive research highlighting their ecotoxicological impacts on many animals. These investigations have demonstrated that MPs influence many groups of creatures inhabiting distinct trophic levels and ecological niches within aquatic food webs. Crustaceans, fish, molluscs, annelids, echinoderms, and rotifers are among the most extensively researched taxa in this context (De Sá et al., 2018) (Table 2). Microplastics directly or indirectly affect these creatures' eating habits and environments, leading to several detrimental effects on their health, behavior, and survival.

Researchers extensively study crustaceans, especially diminutive species, due to their crucial role as primary consumers in aquatic habitats. These species frequently consume microplastics either from their surroundings or via their feed. Larger crustaceans and fish, occupying intermediate or apex predator roles in food webs, consume prey already polluted with these particles, exposing them to microplastics (De Sá et al., 2018). Fish frequently find Microplastics (MPs) in their gastrointestinal systems and may assimilate them into their tissues, which can lead to complications like reduced feeding efficiency, compromised digestion, and potential toxicological effects from chemicals seeping from the plastics (Sunny et al., 2021). The contamination of fish with microplastics poses significant concerns regarding trophic transfer and human exposure to these contaminants.

Molluscs, especially filter-feeding species like mussels, oysters, and clams, are particularly vulnerable to microplastic pollution. These creatures provide a crucial ecological function in water filtration and nutrient cycling; yet, their feeding habits render them susceptible to microplastic ingestion. MPs accumulate in tissues, impacting physiological functions such as eating, development, and reproduction (Mattsson et al., 2017). The consumption of microplastics by molluscs has significant ecological and economic implications, as these organisms are essential for sustaining aquatic ecosystems and are foundational to numerous commercial fisheries. People extensively consume species like Mytilus edulis (common mussel), which serves as a direct conduit for microplastics to infiltrate human diets (De Sá et al., 2018).

Benthic creatures, including annelid worms and echinoderms, encounter microplastics primarily because of their sediment-dwelling characteristics and feeding behaviors (De Sá et al., 2018). These creatures engage with microplastics that accumulate in the sediment, resulting in bioaccumulation. Annelid worms, essential for nutrient cycling and sediment aeration, are especially susceptible to microplastic ingestion, potentially impairing their feeding and burrowing functions (Mattsson et al., 2017). Documents show that echinoderms like sea urchins and holothurians (sea cucumbers) consume microplastics during sediment feeding, potentially affecting their survival and ecosystem roles.

Planktonic species, such as zooplankton and rotifers, constitute the foundation of aquatic food webs and are essential for sustaining ecological health. These species frequently consume MPs due to their diminutive size and resemblance to food particles. Rotifers, functioning as primary consumers, are especially susceptible to microplastic ingestion, which can adversely affect their reproductive success and survival rates (Mattsson et al., 2017). Microplastic contamination of plankton has cascading impacts on the entire food web, as higher trophic levels prey upon these species.

3.5 Interactive eco-toxicological effects of MPs with other contaminants

The ecotoxicological consequences of microplastics (MPs) interacting with other environmental pollutants have been receiving increasing attention in research. These research studies investigate the intricate interactions between MPs and diverse contaminants, either exacerbating or alleviating their effects on aquatic life. The fact that organisms in natural habitats rarely encounter a single contaminant drives this research (De Sá et al., 2018; Kuddus et al., 2021). Instead, they confront a mixture of pollutants that interact with microplastics, leading to cumulative effects that may have extensive ecological and toxicological consequences. Table 3 presents a summary of these connections.

Polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and dichlorodiphenyltrichloroethanes (DDT and its breakdown products) are examples of legacy persistent organic pollutants (POPs). They are very stable and last a long time (De Sá et al., 2018; Kuddus et al., 2020). The extensive surface area and nonpolar characteristics of MPs enable them to adsorb hydrophobic chemical molecules. This adhesion can cause persistent organic pollutants (POPs) to build up in large amounts on the surfaces of microplastics (MPs), turning them into vehicles for pollutant transport. Upon ingestion by aquatic creatures, these contaminated microplastics can release persistent organic pollutants into the organism's systems, potentially resulting in numerous detrimental effects, including endocrine disruption, carcinogenicity, and reproductive toxicity (Salam et al., 2024).

We have thoroughly examined the interactions of MPs with heavy metals, including silver, chromium VI, and nickel. MPs can bind metals via physical adsorption or chemical interactions, forming complexes that may exhibit greater toxicity than the individual constituents (Chen et al., 2017). Researchers have demonstrated that the combination of Chromium VI, a highly poisonous metal, with microplastics enhances its bioavailability and toxicity in aquatic creatures. Such interactions may result in oxidative stress, DNA damage, and compromised physiological processes in affected species. Moreover, MPs can function as vectors, facilitating the accumulation of metals in regions where they would not typically manifest and thus intensifying environmental pollution (De Sá et al., 2018).

Members of Parliament are also actively involved in addressing emerging contaminants, including antibiotics and herbicides, which are becoming increasingly prevalent in aquatic environments (Sazzad et al., 2023). Research has shown the synergistic effects of microplastics with antibiotics such as cephalexin and triclosan. MPs can absorb these antibiotics, extending their longevity in the environment and enabling their consumption by aquatic species. Microplastics that contain antibiotics have been linked to changes in gut microbiota and the possible development of antibiotic resistance in aquatic organisms. This poses major threats to public health and the stability of the environment (Sunny et al., 2021). Similarly, researchers have found that MPs interact with herbicides like paraquat, a widely used agricultural agent. These interactions can augment the toxicity of herbicides by improving their absorption. When organisms consume paraquat-contaminated microplastics, they may endure increased oxidative stress and metabolic disturbance, exacerbating ecosystem imbalances (Lu et al., 2016).

Endocrine-disrupting chemicals (EDCs), including pharmaceutical 17α-ethinylestradiol and bisphenol A, represent another category of pollutants that interact with microplastics (MPs). These substances can imitate or disrupt natural hormones, resulting in developmental, reproductive, and behavioral problems for aquatic creatures. MPs can act as vectors for EDCs, enhancing their bioavailability and distribution within aquatic ecosystems. When microplastics with endocrine-disrupting chemicals are eaten, they can release these chemicals into the body's tissues (Lu et al., 2016). This can cause a number of endocrine-related disorders, such as male fish becoming female, less success reproducing, and changes in growth patterns. The interactions between MPs and these pollutants transpire through many processes, including adsorption, chemical bonding, and surface contacts. The diminutive size, extensive surface area, and chemical makeup of MPs provide them as ideal transporters for both hydrophobic and hydrophilic contaminants (Chen et al., 2017). Upon ingestion, these pollutant-laden microplastics can serve as a source of sustained exposure, releasing toxins into the organism's system and inducing lasting harmful consequences (Mattsson et al., 2017).

3.6 Routes of Human Exposure

Human exposure to microplastics (MPs) transpires via multiple channels, and increasing data indicates that these particles provide considerable dangers to human health. One of the most prevalent pathways of exposure is dietary intake, especially via the eating of seafood and other food items (Ma et a., 2016). Recent research has identified other routes, including drinking water and airborne particles, that increase the risk for injury (Sunny et al., 2022). The health consequences of MPs are becoming increasingly evident, encompassing inflammation, oxidative stress, and disturbances in hormonal and immunological processes (Mattsson et al., 2017).

A primary pathway for human exposure to microplastics is via dietary consumption. People widely recognise shellfish, a type of seafood, as a significant source of microplastic contamination. Species that feed on filters, like mussels, oysters, and clams, are particularly vulnerable to absorbing microplastics. These particles can accumulate in their tissues and spread to humans through consumption (Ma et a., 2016; Lu et al., 2016). Researchers have discovered microplastics in fish, especially those at elevated trophic levels, due to their bioaccumulation from contaminated prey.

Table 1. The application of plastics and their major components (De Sá et al., 2018)

Plastics	Application
Polyethylene terephthalate (PET)	Water and soft drink bottles, food jar
Polyvinyl chloride (PVC)	Cables, plumbing pipes
High-density polyethylene (HDPE)	Shampoo bottles, packaging
Low-density polyethylene (LDPE)	Grocery bags, packaging
Polypropylene (PP)	Medicine bottles and caps, chips packs
Polystyrene (PS)	Disposal cups, cutlery, packaging foam
Polycarbonate (PC)	Food packaging, electronic and defense gadgets
Nylon	Fishing nets, clothing, ropes

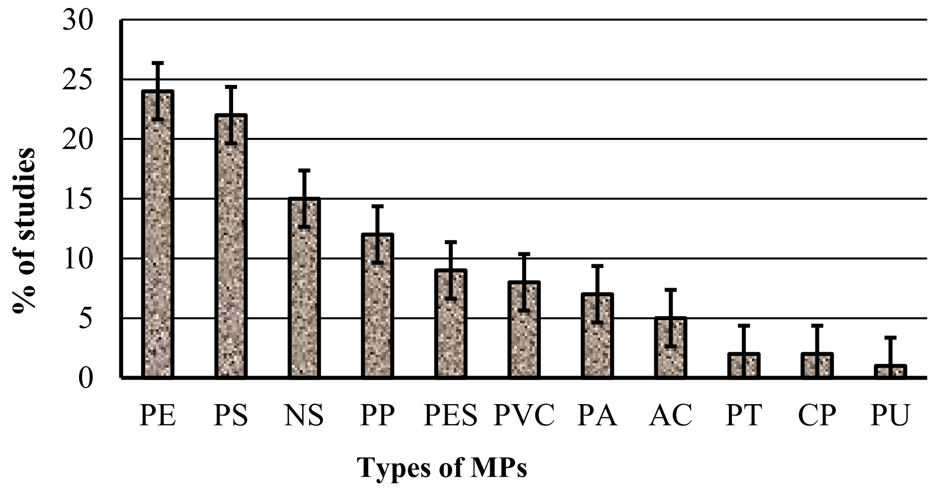

Figure 1. Different types of micro-plastics studied in field and laboratory (%) where PE-Polyethylene; PS-Polystyrene; NS-Not specified; PP-Polypropylene; PES-Polyester; PVC-Polyvinylchloride; PA-Polyamide; AC-Acrylic; PT-Polyether; CP-Cellophane; PU-Polyurethane (Martínez-Gómez et al., 2017; De Sá et al., 2018).

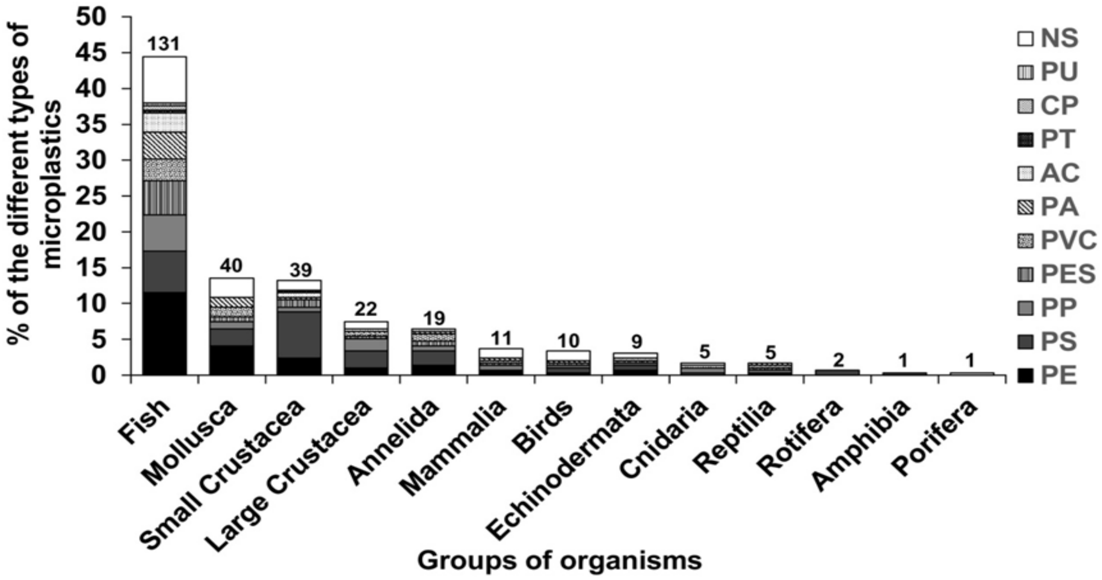

Figure 2. Different types of micro-plastics studied per group of organisms (%). Every bar has the total number of studies where NS-Not specified; PU-Polyurethane; CP-Cellophane; PT- Polyether; AC-Acrylic; PA-Polyamide; PVC-Polyvinylchloride; PES-Polyester; PP-Polypropylene; PS-Polystyrene; PE-Polyethylene (Martínez-Gómez et al., 2017; De Sá et al., 2018).

Table 2. Eco-toxicological effects of MPs across several groups of organisms (Lu et al., 2016; Chen et al., 2017; Mattsson et al., 2017)

Classes	MPs type	Effects
Fish	PE	↓ Total protein, globulin, cholesterol, and triglyceride levels ↑ Mortality ↑ CYP P450 ↓ AChE activity ↓ Predatory performance ↓ Predatory efficiency
	PS	↓ Body length ↓ Larval locomotion ↓ AChE activity ↑Alterations of metabolic profiles ↑Lipid and energy metabolism disturbed ↑Inflammations and lipid accumulation in the liver ↓ Activity ↑ Weight loss in the brain ↓ Water in the brain
	PVC	↑ Peroxidase activity and skin mucus ↑ Phagocytic capacity ↑ genes related to stress ↑ Structural alterations of the Distal intestine ↓ The regular structure of serosa,
Crustacean	PE	↑ Mortality ↓ Reproduction ↓ Growth
	PS	↑ Mortality ↓ Survival ↓ Fecundity ↓ Ingestion rates ↓ Hemolymph sodium ions ↑ Hemolymph calcium ions ↑ Oxygen consumption
	PP	↓ Feeding rate ↓ Body mass ↓ Metabolic rate ↑ Mortality ↓ Growth ↓ Weight
	PVC	↑ Mortality ↓ Settlement
	PES	↑ Mortality ↓ Settlement ↓ Wet weight gain
	PA	↓ Assimilation efficiency
	AC	↑ Immobilization

Table 2. Continuous

Mollusks	PE	↑ Energy consumption ↑ MPs accumulation ↓ AChE and Catalase activities ↓ Lysosomal integrity ↓ the gene involved in immunity
	PS	↑ Maintenance costs ↓ Oocyte number ↓ Sperm velocity ↓ Filtering activity ↓ Phagocytic activity ↑ Apoptotic processes
Annelida	PE	↑ Energy consumption ↓ Protein content
	PS	↓ Feeding activity
	PVC	↓ Energy reserves ↓ Feeding activity ↑ Phagocytic activity ↑ Inflammatory response ↓ Lipid reserves ↑ MPs retention ↑ Oxidative stress
Echinoderms	PE	↑ Anomalous larvae development
	PS	↓ Fertilization rate ↓ Growth ↑ Larval development abnormalities ↑ Oxidative stress ↑ MPs accumulation ↑ Malformations ↑ Disruption of cell membrane
Rotifers	PS	↓ Growth rate ↓ Fecundity ↓ Lifespan ↑ Reproduction time

↑=increase, ↓=decrease

Table 3. Interactions of MPs with other contaminants (Ma et a., 2016; Chen et al., 2017)

Classes	MPs type	Contaminants	Effects of the interaction
Fish	PE	Silver	↑ Ag accumulation ↑ Oxidative stress
		PAHs,	↑Glycogen depletion in liver ↑Single-cell necrosis in liver ↓reduced fecundity ↓anti-estrogenic effect
		Chromium (VI)	↓ Predatory performance ↓ AChE activity ↑ Lipid oxidation levels
		PCBs, PBDEs	↑Genotoxicity ↑Cytotoxicity ↓reduced fecundity
		Cefalexin	↓ PEPP ↑ AChE activity ↑ LPO levels
		Paraquat	↑Biotransformation of enzyme increase ↑ Paraquat toxic effects
	PS	17α-ethinylestradiol	↓Hypoactivity of the locomotion ↓ Body length (involved in the visual system) (genes involved in the nervous system) ↓ AChE activity
		Bisphenol A	↑ BPA uptake (involved in the nervous system) ↑ Dopamine contents
	PVC	PAHs	↑ Oxidative damage
		17α-ethinylestradiol	↓(reduced fecundity)
	PE	PAHs	↑ Mortality ↓ Jumping height
	PS	PAHs	↑ Bioaccumulation of Phenanthrene (Contaminant accumulation)
		Nickel	↑ Immobilization (Behavioral effect)
		PCB,DDT,DDE	↑ Energy consumption ↓ Food consumption
	PE	PAHs	↑ Mortalities ↑Oxidative stress ↑ Abnormal embryo ↓ Lysosomal integrity ↓ AChE activity in gills ↑ Nuclear anomalies
Crustacea	PS	PAHs	↑ Hemocyte mortality ↑Oxidative stress ↑Blood and haemolymph parameter imbalance

Table 3. Continuous

Mollusca	PVC	PAHs	↑ Mortality ↓ Filtration rate ↓ Respiration rate
Annelida	PS	PCBs	↓ Feeding activity ↓ Weight ↓ Energy efficiency
	PVC	Triclosan	↑ Mortality

↑=increase, ↓=decrease

Author contributions

M.H.M. conceptualized the study and provided oversight throughout the project. M.F.B.S. and S.A.S. designed the methodology and carried out the primary data collection. M.B. performed the data analysis and interpretation. S.S. and A.M.F. contributed to the drafting of the manuscript. A.J. and A.R.S.* critically reviewed the manuscript for intellectual content. R.I. and A.A. assisted with the literature review and graphical representations. All authors have read and approved the final manuscript.

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The authors have no conflict of interest.

References

Ashakin, M. R., Bhuyian, M. S., Hosain, M. R., Deya, R. S. & Hasan, S.E. (2024). Transforming to Smart Healthcare: AI Innovations for Improving Affordability, Efficiency, and Accessibility. Pathfinder of Research, 2(2), 1-12

Bhattacharya, R. R. N., Chandrasekhar, K., Roy, P., & Khan, A. (2018). Challenges and opportunities: plastic waste management in India.

Chen, Q., Gundlach, M., Yang, S., Jiang, J., Velki, M., Yin, D., & Hollert, H. (2017). Quantitative investigation of the mechanisms of microplastics and nanoplastics toward zebrafish larvae locomotor activity. Science of the total environment, 584, 1022-1031.

De Sá, L. C., Oliveira, M., Ribeiro, F., Rocha, T. L., & Futter, M. N. (2018). Studies of the effects of microplastics on aquatic organisms: what do we know and where should we focus our efforts in the future?. Science of the total environment, 645, 1029-1039.

Espinosa, C., Cuesta, A., & Esteban, M. Á. (2017). Effects of dietary polyvinylchloride microparticles on general health, immune status and expression of several genes related to stress in gilthead seabream (Sparus aurata L.). Fish & shellfish immunology, 68, 251-259.

Ifty, S.M.H, Bayazid, H., Ashakin, M.R., Tusher, M.I., Shadhin, R. H., Hoque, J., Chowdhury, R. & Sunny, A.R. et al. (2023b). Adoption of IoT in Agriculture - Systematic Review, Applied Agriculture Sciences, 1(1), 1-10, 9676

Ifty, S.M.H., Irin, F., Shovon, M.S.S., Amjad, M.H.H., Bhowmik, P.K., Ahmed, R., Ashakin, M.R., Hossain, B., Mushfiq, M., Sattar, A., Chowdhury, R. & Sunny, A.R. (2024). Advancements, Applications, and Future Directions of Artificial Intelligence in Healthcare, Journal of Angiotherapy, 8(8), 1-18, 9843, 10.25163/angiotherapy.889843

Ifty, S.M.H.,, S.M., Ashakin, M.R., Hossain, B., Afrin, S., Sattar, A., Chowdhury, R., Tusher, M.I., Bhowmik, P.K., Mia, M.T., Islam, T., Tufael, M. & Sunny, A.R. (2023a). IOT-Based Smart Agriculture in Bangladesh: An Overview. Applied Agriculture Sciences, 1(1), 1-6. 9563, 10.25163/agriculture.119563

Khatun, M. S., Apu, S. A., & Foysal, M. M. H. (2024a). Strategies to Minimize Health Worker Issues for HealthcareDelivery at Kurmitola General Hospital (KGH) Dhaka, Bangladesh. Pathfinder of Research, 2(1).

Khatun, M. S., Apu, S. A., & Foysal, M. M. H. (2024b). Proportion of Knee Injuries Among the Army Population AttendingOrthopedic Department, Combined Military Hospital, Dhaka. Pathfinder of Research, 2(1).

Kim, D., Chae, Y., & An, Y. J. (2017). Mixture toxicity of nickel and microplastics with different functional groups on Daphnia magna. Environmental science & technology, 51(21), 12852-12858.

Kuddus, M. A., Alam, M. J., Datta, G. C., Miah, M. A., Sarker, A. K., & Sunny, M. A. R. (2021). Climate resilience technology for year round vegetable production in northeastern Bangladesh. International Journal of Agricultural Research, Innovation and Technology (IJARIT), 11(2355-2021-1223), 29-36.

Kuddus, M. A., Datta, G. C., Miah, M. A., Sarker, A. K., Hamid, S. M. A., & Sunny, A. R. (2020). Performance study of selected orange fleshed sweet potato varieties in north eastern bangladesh. Int. J. Environ. Agric. Biotechnol, 5, 673-682.

Lu, Y., Zhang, Y., Deng, Y., Jiang, W., Zhao, Y., Geng, J., ... & Ren, H. (2016). Uptake and accumulation of polystyrene microplastics in zebrafish (Danio rerio) and toxic effects in liver. Environmental science & technology, 50(7), 4054-4060.

Ma, Y., Huang, A., Cao, S., Sun, F., Wang, L., Guo, H., & Ji, R. (2016). Effects of nanoplastics and microplastics on toxicity, bioaccumulation, and environmental fate of phenanthrene in fresh water. Environmental Pollution, 219, 166-173.

Martínez-Gómez, C., León, V. M., Calles, S., Gomáriz-Olcina, M., & Vethaak, A. D. (2017). The adverse effects of virgin microplastics on the fertilization and larval development of sea urchins. Marine environmental research, 130, 69-76.

Mattsson, K., Johnson, E. V., Malmendal, A., Linse, S., Hansson, L. A., & Cedervall, T. (2017). Brain damage and behavioural disorders in fish induced by plastic nanoparticles delivered through the food chain. Scientific reports, 7(1), 11452.

Moniruzzaman, Sazzad, S. A., Hoque, J., & Sunny, A. R. (2023). Influence of Globalization on Youth Perceptions on ChangingMuslim Rituals in Bangladesh. Pathfinder of Research, 1 (1), 11-22.

Peda, C., Caccamo, L., Fossi, M. C., Gai, F., Andaloro, F., Genovese, L., ... & Maricchiolo, G. (2016). Intestinal alterations in European sea bass Dicentrarchus labrax (Linnaeus, 1758) exposed to microplastics: preliminary results. Environmental pollution, 212, 251-256.

Salam, M.T., Bari, K.B., Rahman, M.M., Gafur, D.M.M., Faruk, M.O., Akter, K., Irin, F., Ashakin, M.R., Shaikat, T.A., Das, A.C., Tufael, M., Mithun, M.M. & Sunny, A.R. (2024). Emergence of Antibiotic-Resistant Infections in ICU Patients, Journal of Angiotherapy, 8(5), 1-9, 9560

Sazzad, S. A. S. S. A., Ana, R. A. R. S. R., Shawon, R., Moniruzzaman, M., Hussain, M. H. M., & Zaman, F. Z. F. (2024). Climate Change and Socioeconomic Challenges of FishingCommunities in the Coastal District of Shariatpur in Bangladesh. Pathfinder of Research, 2(1).

Sazzad, S. A., Billah, M., Sunny, A. R., Anowar, S., Pavel, J. H., Rakhi, M. S., ... & Al-Mamun, M. A. (2023). Sketching Livelihoods and Coping Strategies of Climate Vulnerable Fishers. Egyptian Journal of Aquatic Biology & Fisheries, 27(4).

Sleight, V. A., Bakir, A., Thompson, R. C., & Henry, T. B. (2017). Assessment of microplastic-sorbed contaminant bioavailability through analysis of biomarker gene expression in larval zebrafish. Marine pollution bulletin, 116(1-2), 291-297.

Straub, S., Hirsch, P. E., & Burkhardt-Holm, P. (2017). Biodegradable and petroleum-based microplastics do not differ in their ingestion and excretion but in their biological effects in a freshwater invertebrate Gammarus fossarum. International journal of environmental research and public health, 14(7), 774.

Sunny, A. R., Mithun, M. H., Prodhan, S. H., Ashrafuzzaman, M., Rahman, S. M. A., Billah, M. M., ... & Hossain, M. M. (2021). Fisheries in the context of attaining Sustainable Development Goals (SDGs) in Bangladesh: COVID-19 impacts and future prospects. Sustainability, 13(17), 9912.

Sunny, A. R., Reza, M. J., Chowdhury, M. A., Hassan, M. N., Baten, M. A., Hasan, M. R., ... & Hossain, M. M. (2022). Biodiversity assemblages and conservation necessities of ecologically sensitive natural wetlands of north-eastern Bangladesh. Indian Journal of Geo-Marine Sciences (IJMS), 49(01), 135-148.