Microplastics Pollution in Fish and Aquatic Ecosystems; Sources, Impacts and Human Health Risks

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Abstract

Microplastic pollution has emerged as one of the most pressing environmental challenges of the 21st century, particularly in aquatic ecosystems where it poses significant ecological and human health risks. This paper reviews the sources, pathways, and impacts of microplastic contamination with a focus on their occurrence in fish and aquatic environments such as the Lagos and Epe Lagoons in Nigeria. Microplastics, defined as plastic particles smaller than 5 mm, originate from both primary sources (e.g., microbeads, textile fibers) and secondary sources such as the degradation of larger plastic debris. Their persistence enables bioaccumulation and trophic transfer within aquatic food webs. Ingested by fish and benthic organisms, microplastics impair growth, reproduction, and immune responses while also acting as vectors for toxic substances such as persistent organic pollutants (POPs), phthalates, and heavy metals. The implications for human health are increasingly concerning as seafood consumption and water quality are directly affected. Studies indicate potential links between microplastic exposure and oxidative stress, inflammation, and carcinogenicity. Lagos Lagoon, heavily impacted by poor waste management and urbanization, exemplifies the socio-economic and ecological costs of microplastic pollution. This paper highlights emerging detection technologies, regulatory gaps, and management strategies including improved waste management, recycling, and public awareness. It concludes with recommendations for multi-sectoral collaboration and research to mitigate risks and protect aquatic ecosystems and human health.

Keywords: Microplastics, Pollution, Fish, Aquatic Ecosystems, Human Health

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Introduction

Plastics are ubiquitous environmental pollutants that accumulate in marine, freshwater, and terrestrial ecosystems (Adeniyi & Yusuf 2019). In developing countries, the production, usage, and improper disposal of plastics have led to an increase in environmental pollution (Adeogun et al., 2018). Over the years, plastic products have become widely and extensively used across various sectors, including agriculture, industry, and personal care. In 2020, global plastic production surpassed 360 million tons and is projected to reach 1.1 billion tons by 2050. A significant portion of this plastic, over 79%, is classified as single-use and is often discarded into the environment (Alava, 2020). This waste and its improper disposal have raised concerns about plastic waste pollution.

As plastics degrade, they fragment into smaller particles, with those less than 5 mm in size referred to as microplastics (Ali et al., 2022). Microplastics can be produced by degrading fragments of major plastics or as raw material to manufacture plastics. Several recent investigations have emphasized the potential environmental and health hazards microplastics pose, prompting further research into their distribution, sources, and persistence in different environments (Aransiola et al., 2024). Due to their large surface area and hydrophobic nature, microplastics can act as vectors for various contaminants, including toxic heavy metals, pathogens, and chemical pesticides.

This increase in microplastics has led researchers to identify and classify plastics and microplastics as important threats to marine and aquatic environments (Bacha et al., 2021). In recent years, global plastic production has surged to 359 metric tons (Mt) from 348 (Mt) in just two years. More so, the global plastic manufacturing industry has expanded significantly from a mere 0.5 Mt per year in the 1960s to 348 Mt in 2017, paving the way for the present global abundance of plastic items (Barboza et al. 2020). Projections suggest that by the year 2030, plastic emissions released into the aquatic environment will hit 53Mt across 173 countries of the world (Akintan et al., 2019). A significant portion of plastic waste (between 4.8 and 12.7 million Mt) will end up in the world’s oceans, intensifying marine pollution. Due to its wide-ranging impact on ecosystems, plastic pollution has become a dominant global issue. These plastic fragments are categorized by size, including nanoplastics (<0.001 mm), microplastics (MPs, ≥0.001 mm and <5 mm), mesoplastics (≥5 mm and <25 mm), and macroplastics (≥25 mm) (Amaral-Zettler et al., 2020). The adverse effects of macroplastics through entanglement, choking, and strangulation of animals are some of the well-documented impacts of macroplastics (Adeogun et al., 2022). Macroplastics are often considered the face of plastic pollution because of their large size, which makes them more recognizable and impactful in illustrating the scale of plastic waste.

Microplastics have been recognized as the most prevalent form of solid waste on Earth even as they are almost invisible to the naked eye (Duan et al., 2022). Microplastics are complex, with many different constituent chemical mixtures and contaminants as components (Deng et al., 2017). Due to their minute size, they are easily ingested by a wide range of marine organisms, including fish and plankton, leading to varying levels of ecological disruption (Davidson, 2012). The ingestion of microplastics can cause physical harm, reduce feeding, impair growth, and negatively affect reproduction in aquatic species (Ogunbiyi, 2021).

Microplastics have been found to be vectors of poisonous substances, such as persistent organic pollutants (POPs), heavy metals and pathogenic microorganisms, which can enter the food web when marine organisms ingest these particles (d’Ambrieres, 2019). When marine species ingest these microplastics, they are also exposed to these toxins, which can bioaccumulate in their tissues, potentially leading to physiological stress, oxidative damage, and impaired immune function (Ciscato et al., 2018). The consumption of contaminated seafood by humans raises concerns about health risks, including inflammation, oxidative stress, and potential cellular toxicity. Although the full extent of these health implications is still under scientific investigation, the existing findings suggest a need for further research into the origin, distribution, sources, and fate of microplastics in various environments (Chowdhury et al., 2021).

One significant challenge in assessing the potential health hazards of microplastics to humans stems from the limited availability of extensive data regarding the extent to which people are exposed to microplastics (Adeogun et al., 2020). This gap is largely due to the ongoing and continuous development of techniques for accurately measuring MPs in the air, water, food, and cosmetics (Chen et al., 2021). Moreover, the current detection method, primarily based on spectroscopy, typically describes microplastics (such as items, fibres, or particles) in terms of their count, size, and shape, whereas in the field of exposure science, doses are usually expressed in terms of their mass (Alava, 2020). This inconsistency presents a significant barrier to understanding fully the health risks posed by microplastics to human well-being.

This paper adopts a narrative review approach. Relevant peer-reviewed articles, reports, and policy documents were sourced from databases such as Scopus, Web of Science, and Google Scholar. Search terms included 'microplastics', 'fish', 'aquatic ecosystems', 'Lagos Lagoon', 'Epe Lagoon', and 'human health risks'. The review focused on studies published between 2010 and 2024.

Sources and Pathways of Microplastic pollution

Microplastics are classified as primary (intentionally manufactured small particles such as microbeads and fibers) and secondary (fragments from degradation of larger plastics). They enter aquatic environments via urban runoff, wastewater effluents, atmospheric deposition, and agricultural activities (Auta et al., 2017). Lagos Lagoon, with its dense population and weak waste management, is a hotspot of microplastic contamination. MPs serve as vectors for toxic chemicals including POPs, PAHs, heavy metals, and endocrine disruptors, further compounding their ecological and health risks (Fasuyi et al., 2021).

The presence of microplastics in surface and benthic waters has been documented across various ecosystems. Microplastics in water bodies can be transported over long distances by currents, and their accumulation in the water column poses a threat to aquatic organisms. Research has shown that microplastics tend to concentrate in coastal areas and estuaries due to human activity, making lagoons such as Lagos Lagoon hotspots for pollution (Fatoki et al., 2020).

In a study conducted in the Mediterranean, it was reported that the concentration of microplastics in surface waters ranged from 0.3 to 0.9 items per cubic meter. This highlights the widespread nature of microplastic contamination in coastal environments, with similar concentrations expected in highly urbanized and industrialized regions like Lagos (Davidson & Dudas, 2017). The physical and chemical properties of microplastics, such as density and size, influence their distribution in water bodies, with lighter plastics tending to float and accumulate at the surface, while denser particles settle in the sediment (Elgarahy et al., 2021).

Several Nigerian studies have documented the occurrence of microplastics in aquatic systems, with findings summarized in Table 1. For instance, Olarinmoye et al. (2020) reported concentrations of 139–303 particles/L in Lagos Lagoon surface waters and 310–2319 particles/kg in sediments, with fibres being the dominant type. Adeogun et al. (2020) found that nearly 70% of commercial fish from Eleyele Lake contained microplastics, with an average of 1–6 particles per fish. More recent studies, such as Dada and Bello (2023), confirmed microplastics in three carnivorous fish species from Lagos Lagoon but not in the herbivorous *O. niloticus*. Adenuga et al. (2022) further reported 108–199 particles/L in Badagry Lagoon waters and 283–315 particles/kg in sediments. Collectively, these studies highlight the widespread and growing concern of microplastic contamination across Nigerian aquatic environments.

Impact on Fish and Aquatic Ecosystems

Fish ingest microplastics either directly from water or indirectly through contaminated prey. Documented impacts include gut blockage, reduced feeding efficiency, inflammation, oxidative stress, and impaired reproduction. Microplastics also alter aquatic habitats by increasing turbidity, reducing light penetration, and disrupting microbial communities. Filter feeders such as mussels and benthic organisms are particularly vulnerable, with high concentrations of MPs detected in sediments and coastal waters (Olarinmoye et al., 2020).

The environmental impacts of microplastic pollution are extensive, affecting aquatic organisms at all trophic levels as shown in table 1. Beyond ingestion by fish, microplastics can be ingested by plankton, filter feeders, and other marine organisms, leading to bioaccumulation and biomagnification throughout the food web (Adeogun et al., 2020). The attachment of toxic substances, such as persistent organic pollutants (POPs), to microplastic particles further amplifies their harmful effects, as these toxins can be transferred to organisms that ingest the particles.

Table 1: Selected Nigerian microplastics studies (2019–2024)

Study (Author, Year)	Waterbody / Location	Matrix	Reported abundance (units)	Dominant shapes / polymers	Notes
Olarinmoye et al., 2020	Lagos Lagoon (Nigeria)	Surface water; Sediment	Water: 139–303 particles/L Sediment: 310–2319 particles/kg	Fibres dominant (water ~93%); fragments & films more in sediment. Polymers: PP, PE prevalent	Urbanized sites; fine-grained Makoko sediment highest.
Dada & Bello, 2023	Lagos Lagoon (Nigeria)	Water; Sediment; Fish (H. odoe, C. nigrodigitatus, O. niloticus, L. maximus)	Qualitative: MPs detected in water/sediment and 3 carnivorous fishes; none in herbivorous O. niloticus	Fibres more in water; fragments in sediment	Links pollution to recreational, industrial, domestic sources.
Adeogun et al., 2020	Eleyele Lake, Ibadan (Nigeria)	Fish (8 commercial spp.)	69.7% of fish contained MPs; ~1–6 MPs/fish on average (max 34); size 124 µm–1.53 mm	—	Prevalence highest in O. niloticus and C. zillii.
Adenuga et al., 2022 (Badagry Lagoon)	Badagry Lagoon (Lagos State, Nigeria)	Surface water; Sediment	Water: 108–199 particles/L (site range) Sediment: 283–315 particles/kg	Shapes varied by site	Health risk discussion based on polymer types.

Note: Abundance units are reported as in the cited studies.

As summarized in table 1, many Nigerian studies have documented microplastics in surface waters, sediments, and fish, with concentrations ranging from 108–303 particles/L in water to over 2300 particles/kg in sediments.

Human Health Risks

• Ingestion: MPs enter the body through contaminated seafood, water, and salt.

• Inhalation: Airborne MPs can be inhaled, especially fibers from textiles and dust.

• Dermal contact: MPs from cosmetics or personal care products can enter through skin.

From a human health perspective, the ingestion of microplastics by fish and other seafood poses potential risks. Although research on the direct health effects of microplastic consumption by humans is still ongoing, concerns have been raised about the potential for toxic chemicals associated with microplastics to accumulate in human tissues. Recent studies have shown that microplastics can enter the human body through the consumption of contaminated seafood, drinking water, and even air[7].

Case Study: Lagos and Epe Lagoons

The Lagos Lagoon complex, including Epe Lagoon, is one of the most important inland water bodies in West Africa. It supports fisheries, aquaculture, recreation, and transportation for millions of residents. Rapid urbanization, industrial discharge, and population growth have made the system highly vulnerable to pollution. Studies in the lagoons report MPs in both surface waters and sediments, as well as in fish species such as Oreochromis niloticus (tilapia) and Clarias gariepinus (African catfish), which are staple foods in Nigeria (Adada & Adeogun, 2023).

The ingestion of MPs by these commercially valuable species has direct implications for food safety and economic livelihoods. Communities dependent on fisheries face reduced productivity and income as fish quality and quantity decline. Ecologically, MPs exacerbate water quality deterioration, biodiversity loss, and ecosystem imbalance (Ogunbiyi, 2021). Weak enforcement of environmental laws and inadequate waste infrastructure compound the challenge. The Lagos and Epe Lagoons exemplify the broader global issue of microplastic pollution in developing regions.

Recent studies have confirmed the presence of microplastics in both surface waters and benthic sediments of the Lagos and Epe Lagoons. Fibers, fragments, and films are the most commonly reported types, largely derived from synthetic textiles, packaging waste, fishing gear, and degraded single-use plastics (Ogundele et al., 2021). Fish species such as *Oreochromis niloticus* (Nile tilapia) and *Clarias gariepinus* (African catfish), which form a substantial part of the local diet, have been shown to ingest MPs in varying quantities. The ingestion process is linked to similarities between MPs and natural prey items, such as zooplankton, in terms of size and coloration (Balogun & Ajani, 2021).

The contamination of these ecosystems has several ecological consequences. MPs in fish tissues impair growth, feeding efficiency, and reproduction, thereby affecting fish population dynamics. At the ecosystem level, MPs increase turbidity, alter microbial communities, and facilitate the spread of pathogens through biofilm formation. The lagoons, already under stress from nutrient loading, oil pollution, and heavy metals, are further burdened by the persistence of MPs, leading to compounded ecological risks (Ogundele et al., 2021).

A synthesis of available data for the Lagos–Epe lagoon complex is presented in Table 2. Reported concentrations range from 139–303 particles/L in Lagos Lagoon surface waters to 310–2319 particles/kg in sediments, with Makoko showing the highest loads (Olarinmoye et al., 2020). Badagry Lagoon, part of the same system, recorded 108–199 particles/L in water and 283–315 particles/kg in sediments (Adenuga et al., 2022). In fish, Dada and Bello (2023) confirmed microplastic ingestion in carnivorous species such as *H. odoe*, *C. nigrodigitatus*, and *L. maximus*, while *O. niloticus* showed no detectable MPs. Most recently, a FUNAAB-led study (2024) confirmed microplastics in seafood tissues, surface waters, and sediments from Epe Lagoon, with fibres and fragments being the most common shapes. These findings as displayed in table 2 confirm that the Lagos–Epe lagoon complex is a microplastic hotspot, with implications for both ecosystem health and human food security.

Table 2 presents a synthesis of reported concentrations across the Lagos–Epe lagoon system, highlighting hotspots such as Makoko with sediment loads exceeding 2000 particles/kg.

Table 2: Case study data for the Lagos–Epe lagoon complex (water, sediment, biota)

Sub-system	Matrix	Reported abundance (units)	Dominant shapes / polymers	Key source(s)
Lagos Lagoon (urban reach)	Surface water	139–303 particles/L	Fibres predominant (~93%)	Olarinmoye et al., 2020
Lagos Lagoon (urban reach)	Sediment	310–2319 particles/kg (highest at fine-grained Makoko)	Fragments & films more common; PP, PE prevalent	Olarinmoye et al., 2020
Badagry Lagoon (western sector of Lagos lagoon system)	Surface water	108–199 particles/L (site range)	—	Adenuga et al., 2022
Badagry Lagoon (western sector)	Sediment	283–315 particles/kg	—	Adenuga et al., 2022

Lagos Lagoon fisheries	Fish (carnivores)	Presence confirmed in H. odoe, C. nigrodigitatus, L. maximus; not detected in O. niloticus	Fibres (water) vs fragments (sediment) pattern mirrored in biota exposure context	Dada & Bello, 2023
Epe Lagoon (seafood, water, sediment)	Seafood tissues; water; sediment	Detected across all examined seafood tissues (varying levels); MPs present in water & sediment	Common shapes reported include fibres and fragments	JNSET (FUNAAB), 2024

Note: Items/L and items/kg reflect microscopy counts reported by each study; methodologies varied (e.g., FTIR confirmation subsets). JNSET (2024) paper reports presence and shapes for Epe Lagoon but does not provide a single consolidated concentration range in the abstract.

The Lagos and Epe Lagoons support artisanal and commercial fisheries that directly sustain thousands of households. The contamination of fish stocks by microplastics not only reduces market value but also raises serious food safety concerns. Residents consuming contaminated fish are at risk of exposure to microplastics and their associated toxicants, such as bisphenol A, phthalates, and heavy metals (Odunuga et al., 2018). This has implications for nutrition, public health, and socio-economic stability in Lagos, where fish remains a primary source of affordable protein. Moreover, reduced fish yields and declining water quality negatively impact livelihoods, tourism, and recreation, undermining the economic potential of the lagoons.

Management and Policy Interventions

Future Directions

Future research is needed to understand nanoplastics, long-term toxicological effects of microplastics exposure, and socio-economic impacts in developing countries. Methodological harmonization for detecting microplastics in water, fish and human tissues is also critical. Collaboration between African researchers, policy makers and industry stakeholders can help bridge existing knowledge gaps and strengthen monitoring capacity.

Tackling microplastic pollution requires integrated and multi-level strategies. Globally, interventions include bans on single-use plastics, restrictions on microbeads, and adoption of circular economy approaches. The European Union has pioneered such policies, while the United Nations is working towards a global treaty on plastic pollution. Technological advances in monitoring, such as FTIR and GC-MS, are enhancing detection and data quality.

In Nigeria, the National Environmental Standards and Regulations Enforcement Agency (NESREA) regulate pollution, but weak enforcement and limited infrastructure hinder progress. Recommended strategies include strengthening waste collection and recycling, promoting extended producer responsibility, and investing in sustainable alternatives. Public education campaigns are critical for behavioral change. Regional cooperation among West African nations is also needed to address transboundary pollution. Without urgent and coordinated action, the ecological and health risks posed by MPs will escalate further.

Conclusion and Recommendations

Microplastic pollution represents a pervasive and escalating threat to aquatic ecosystems and human health. Evidence from the Lagos and Epe Lagoons underscores the severity of the issue in developing regions with weak waste management systems. MPs harm fish health, disrupt ecosystems, and potentially impact human health through dietary and environmental exposure. Policymakers must prioritize reducing plastic waste, strengthening waste management systems, and enforcing environmental laws. Researchers should investigate toxicological mechanisms, exposure pathways, and socio-economic effects in greater detail. Engaging communities through education and awareness will be crucial to long-term success. A collaborative, multi-sectoral approach is needed to mitigate the impacts of microplastics and safeguard both the environment and public health.

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