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REVIEW ARTICLE

Microplastic Contamination in *Labeo rohita* and Freshwater Ecosystems: Sources, Occurrence, Biological Impacts, and Food Safety Implications, A Comprehensive Review

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Abstract

Background: Microplastic pollution is a significant environmental challenge for aquatic ecosystems. Freshwater environments act as reservoirs for microplastics (MPs) from domestic, industrial, and urban sources. Freshwater fish, particularly *Labeo rohita* (Rohu), a staple economic species in South Asia, are highly vulnerable to ingestion, serving as ideal bioindicators for contamination. **Objective:** This review summarizes current knowledge regarding the sources, distribution, and biological effects of MPs in freshwater, with specific emphasis on *Labeo rohita*, while identifying critical knowledge gaps. **Review Methodology**: Peer-reviewed literature published between 2014 and 2026 was synthesized using international databases including Web of Science and PubMed. Studies detailing ecological impacts, toxicological mechanisms, and human health implications were evaluated. **Discussion:** Microplastics originate from both primary and secondary sources and enter freshwater ecosystems through wastewater discharge, industrial effluents, agricultural runoff, atmospheric deposition, urban drainage, and degradation of larger plastic debris. Once introduced into aquatic environments, these particles are readily ingested by freshwater organisms and accumulate primarily within the digestive tract, gills, liver, kidneys, and other tissues. Numerous studies have demonstrated that microplastic exposure induces intestinal blockage, oxidative stress, inflammatory responses, tissue damage, immune suppression, endocrine disruption, reproductive impairment, behavioral alterations, and changes in gene expression. Because of its omnivorous feeding habit, ecological importance, and widespread consumption, *Labeo rohita* serves as a valuable sentinel species for monitoring freshwater microplastic pollution and evaluating potential food safety risks associated with trophic transfer. **Conclusion:** Microplastic contamination represents a growing ecological and public health concern that threatens freshwater biodiversity, fish health, ecosystem stability, and food security. The increasing occurrence of microplastics in freshwater fish emphasizes the urgent need for standardized monitoring protocols, improved plastic waste management, and comprehensive toxicological investigations, particularly in developing countries where information remains limited. **Recommendations:** Future research should prioritize standardized analytical techniques, long-term ecological monitoring, evaluation of nanoplastic toxicity, investigation of trophic transfer mechanisms, assessment of edible fish tissues, and development of effective environmental policies aimed at reducing plastic pollution. Strengthening public awareness, improving waste management infrastructure, and implementing evidence-based regulatory frameworks are essential for protecting freshwater ecosystems and ensuring food safety.

Keywords: Microplastics; *Labeo rohita*; Freshwater ecosystems; Fish health; Food safety; Plastic pollution; Bioaccumulation.

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1. Introduction

Plastic production has increased dramatically during the past several decades owing to its versatility, durability, lightweight nature, and relatively low production cost. Although plastics have revolutionized numerous industrial and domestic applications, their persistence in the environment has become a major global concern. Environmental degradation of plastic materials results in the formation of microscopic plastic particles, commonly known as microplastics (MPs), which are generally defined as plastic particles measuring less than 5 mm in diameter. Due to their small size, persistence, and resistance to degradation, microplastics have become ubiquitous contaminants in marine, freshwater, terrestrial, and atmospheric environments [1].

Freshwater ecosystems are particularly vulnerable because they receive large quantities of plastic waste from urban runoff, municipal wastewater, industrial discharge, agricultural activities, and atmospheric deposition. Rivers, lakes, reservoirs, wetlands, and streams not only accumulate microplastics but also transport them toward marine environments, making freshwater systems an important link in the global plastic pollution cycle [2].

Freshwater fish continuously interact with contaminated water, sediments, and food organisms, making them highly susceptible to microplastic ingestion. Once ingested, microplastics may accumulate within the gastrointestinal tract and other internal organs, leading to numerous physiological, biochemical, and pathological alterations. These adverse effects include intestinal obstruction, oxidative stress, inflammation, tissue damage, immune dysfunction, endocrine disruption, reproductive impairment, and behavioral abnormalities. Furthermore, microplastics can adsorb heavy metals, pesticides, antibiotics, and persistent organic pollutants, thereby acting as carriers of additional toxic contaminants within aquatic food webs [3].

Among freshwater fish species, *Labeo rohita* (Rohu) occupies a unique ecological and economic position throughout South Asia, particularly in Pakistan, India, Bangladesh, and Nepal. This species is one of the most commercially valuable members of the family Cyprinidae and contributes substantially to inland fisheries and aquaculture production. Owing to its omnivorous feeding behavior, continuous interaction with sediments and planktonic organisms, and widespread human consumption, *L. rohita* is considered an excellent biological indicator for assessing freshwater microplastic contamination and evaluating potential risks to food safety and public health [4].

2. Environmental Concern and Regional Context

Microplastic contamination has become one of the most pressing environmental issues affecting freshwater ecosystems worldwide. Increasing urbanization, industrialization, rapid population growth, and inadequate plastic waste management have substantially accelerated the release of plastic debris into aquatic environments. Large plastic items gradually undergo physical, chemical, and biological degradation, producing enormous quantities of microplastics that persist for decades due to their exceptional resistance to natural decomposition [5].

Pakistan has experienced considerable growth in plastic consumption during recent decades, while waste management infrastructure has not expanded at a comparable rate. Consequently, significant amounts of plastic waste are discharged into rivers, irrigation canals, lakes, reservoirs, and wetlands, increasing the likelihood of microplastic contamination in freshwater ecosystems [1].

The Indus River system, which represents Pakistan's largest freshwater network, supports diverse aquatic biodiversity and provides drinking water, irrigation, fisheries, aquaculture, and industrial resources for millions of people. However, increasing plastic pollution threatens the ecological integrity of this important river system. Studies have identified substantial quantities of plastic debris throughout the Indus basin, highlighting the urgent need for continuous environmental monitoring and sustainable waste management strategies [7].

Dera Ismail Khan, located in Khyber Pakhtunkhwa Province, possesses numerous freshwater habitats, including rivers, canals, ponds, and wetlands that support economically important fish species such as *Labeo rohita*. These aquatic ecosystems are increasingly exposed to anthropogenic pollutants, including microplastics originating from municipal waste, agricultural runoff, domestic sewage, industrial effluents, and atmospheric deposition. Despite the ecological and economic importance of these freshwater resources, scientific information regarding microplastic contamination in fish populations from this region remains limited [4].

3. Background of Plastic Pollution

Plastic pollution has become one of the fastest-growing environmental problems worldwide. More than 400 million tonnes of plastic are produced annually, with a considerable proportion entering natural ecosystems because of improper disposal, insufficient recycling, and ineffective waste management practices. Since most conventional plastics are resistant to microbial degradation, they persist in the environment for prolonged periods and gradually fragment into progressively smaller particles [8].

Microplastics are generally classified as plastic particles measuring less than 5 mm in diameter and may originate either as intentionally manufactured microscopic particles (primary microplastics) or from the fragmentation of larger plastic products (secondary microplastics). Environmental weathering processes, including ultraviolet radiation, mechanical abrasion, hydrolysis, oxidation, and microbial activity, contribute to the continuous breakdown of larger plastic materials into microplastics [9].

Due to their hydrophobic surfaces and large surface-area-to-volume ratio, microplastics readily adsorb heavy metals, pharmaceuticals, pesticides, antibiotics, and persistent organic pollutants from surrounding environments. Consequently, they serve not only as physical contaminants but also as vectors for transporting hazardous chemicals throughout aquatic ecosystems. Once ingested by aquatic organisms, these contaminated particles may bioaccumulate within tissues and undergo trophic transfer through aquatic food webs, ultimately increasing human exposure through fish consumption [10].

The Indus River has been identified as one of the major global contributors of plastic waste entering marine environments. Surveys conducted along the Upper Indus Basin have demonstrated that plastic debris constitutes a substantial proportion of solid waste collected from riverbanks and surface waters. Single-use plastic products, including shopping bags, beverage bottles, food packaging, disposable containers, and fishing gear, remain the dominant sources of plastic pollution throughout the basin. These observations emphasize the urgent need for improved waste management policies, public awareness campaigns, and environmentally sustainable alternatives to conventional plastic products [11].

This review therefore provides a comprehensive evaluation of current scientific knowledge regarding microplastic contamination in freshwater ecosystems, with particular emphasis on *Labeo rohita*, its ecological significance, biological responses to microplastic exposure, and potential implications for food safety and environmental sustainability.

4. Sources of Micro-plastics

Freshwater ecosystems receive microplastics from numerous anthropogenic sources that differ considerably in origin, transport mechanisms, chemical composition, and environmental persistence. Understanding these sources is essential for developing effective strategies to reduce plastic pollution and protect aquatic biodiversity. Microplastics originate either directly as microscopic particles or indirectly through the fragmentation of larger plastic materials following prolonged environmental exposure [12].

Municipal wastewater treatment plants represent one of the most significant pathways through which microplastics enter freshwater environments. Domestic sewage contains synthetic textile fibers released during washing, cosmetic microbeads, household plastic fragments, cleaning products, and packaging materials. Although wastewater treatment facilities remove a substantial proportion of suspended particles, many microplastics remain sufficiently small to escape filtration systems and are ultimately discharged into rivers, lakes, and reservoirs [13].

Industrial activities also contribute substantially to environmental microplastic contamination. Plastic manufacturing industries, textile factories, packaging industries, paint production, and synthetic polymer processing plants generate considerable quantities of microscopic plastic particles during manufacturing, transportation, and handling processes. Accidental release of industrial plastic pellets (nurdles) has been recognized as an important source of primary microplastics worldwide [14].

Agricultural practices further increase microplastic contamination through the extensive use of plastic mulch films, greenhouse covers, irrigation pipes, fertilizer coatings, and sewage sludge applied as fertilizer. Weathering and mechanical degradation of these plastic materials gradually release microplastics into agricultural soils, from where they are transported into freshwater systems through rainfall, irrigation runoff, and erosion.

Urban stormwater runoff represents another important transport pathway. Rainwater carries plastic litter, road dust, tire wear particles, construction debris, and fragmented packaging materials from urban surfaces into drainage systems and nearby rivers. Tire abrasion alone contributes millions of synthetic polymer particles annually, making road traffic a major source of microplastic pollution [15].

Atmospheric deposition has recently emerged as an additional pathway for microplastic transport. Airborne fibers and plastic particles originating from synthetic textiles, industrial emissions, road dust, and urban activities can be transported over considerable distances before being deposited into freshwater environments through rainfall or dry atmospheric settling.

Fishing and aquaculture activities also introduce plastics into freshwater habitats. Degradation of fishing nets, ropes, cages, floats, feed bags, and other plastic equipment continuously releases synthetic fibers and fragments into surrounding waters, where they become available for ingestion by aquatic organisms [16].

Because freshwater ecosystems receive microplastics from multiple interconnected sources simultaneously, comprehensive pollution control requires integrated management approaches involving improved waste collection, efficient recycling, advanced wastewater treatment technologies, environmentally friendly industrial practices, and public education programs designed to reduce plastic consumption [17].

5. Classification of Micro-plastics

Microplastics are commonly classified according to their origin, size, morphology, polymer composition, and environmental behavior as shown in Fig 1. Among these classification systems, origin-based classification remains the most widely accepted because it provides valuable information regarding pollution sources and environmenta management strategies [1].

5.1. Primary Microplasticsl

Primary microplastics are intentionally manufactured at microscopic sizes for specific industrial, commercial, or domestic applications. These particles are generally smaller than 5 mm before entering the environment. Common examples include industrial plastic pellets (nurdles), cosmetic microbeads, synthetic polymer powders, abrasive cleaning agents, air-blasting media, pharmaceutical carriers, and synthetic textile fibers [6].

Plastic pellets serve as the primary raw material for plastic manufacturing industries and may enter freshwater ecosystems during production, transportation, storage, or accidental spillage. Cosmetic microbeads were previously incorporated into facial cleansers, toothpaste, exfoliating products, and personal care items, although their use has been restricted in many countries because of environmental concerns. Synthetic fibers released during laundering of polyester, nylon, acrylic, and polypropylene textiles are now recognized as one of the largest contributors to primary microplastic pollution [3].

5.2. Secondary Microplastics

Secondary microplastics originate through the fragmentation and degradation of larger plastic materials following prolonged exposure to environmental conditions. Unlike primary microplastics, these particles are not intentionally manufactured at microscopic sizes but develop gradually through weathering processes [8].

Plastic bottles, shopping bags, food packaging materials, fishing nets, ropes, agricultural films, disposable utensils, vehicle tires, construction materials, and household products represent the principal sources of secondary microplastics. Environmental degradation occurs through ultraviolet radiation, thermal oxidation, hydrolysis, mechanical abrasion, wave action, microbial activity, and repeated cycles of heating and cooling. These processes progressively weaken plastic polymers until they fragment into microscopic particles capable of dispersing throughout aquatic ecosystems [13].

Secondary microplastics constitute the majority of plastic particles identified in freshwater environments because of the continuous degradation of improperly discarded plastic waste. Their abundance is expected to increase further with continued growth in global plastic production and inadequate waste management [16].

5.3. Classification According to Shape

Microplastics occur in a variety of morphological forms, including fibers, fragments, films, pellets, foams, granules, and beads. Particle morphology influences environmental transport, settling behavior, ingestion probability, and biological toxicity. Fibers derived from synthetic textiles are among the most frequently detected microplastics in freshwater ecosystems, whereas fragments originating from degraded plastic products are commonly recovered from sediments and fish gastrointestinal tracts [3].

5.4. Classification According to Polymer Type

Microplastics are composed of numerous synthetic polymers, including polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), polyurethane (PU), and nylon. Each polymer exhibits distinct physical and chemical characteristics that influence buoyancy, degradation rate, contaminant adsorption capacity, and toxicity. Polyethylene and polypropylene are generally the most abundant polymers identified in freshwater ecosystems because of their widespread use in packaging materials and consumer products [4].

Understanding the classification of microplastics provides valuable insight into their environmental behavior, ecological distribution, and potential biological effects. Identifying pollution sources and dominant polymer types is fundamental for developing effective monitoring programs, improving waste management strategies, and reducing microplastic contamination in freshwater ecosystems [7].

Fig. 1: Classification of MPs

6. Micro-plastics in Freshwater Ecosystems

Freshwater ecosystems have emerged as important reservoirs and transport pathways for microplastics, receiving contaminants from municipal wastewater, industrial effluents, agricultural runoff, urban stormwater, atmospheric deposition, and the degradation of larger plastic debris as shown in Fig. 2. Rivers, lakes, reservoirs, ponds, and wetlands continuously accumulate and redistribute MPs, facilitating their movement through aquatic food webs. The persistence of these particles is primarily attributed to their resistance to biological degradation and prolonged environmental stability [9].

Microplastics are widely distributed in freshwater sediments, surface waters, and aquatic organisms. Their abundance is influenced by population density, industrial development, waste management practices, hydrological conditions, and seasonal variations. Due to their small size and hydrophobic nature, MPs readily adsorb toxic chemicals, including heavy metals, pesticides, antibiotics, and persistent organic pollutants, thereby increasing their ecological risk [16].

Freshwater organisms are continuously exposed to microplastics through ingestion and direct environmental contact. The accumulation of MPs in aquatic ecosystems has been associated with altered water quality, reduced biodiversity, trophic transfer of contaminants, and disruption of ecosystem functioning. Consequently, freshwater ecosystems serve as critical indicators for assessing environmental plastic pollution and its potential implications for aquatic life and human health [14].

Fig. 2: MPs in Freshwater Ecosystems

7. Occurrence of Micro-plastics in Freshwater Fish

Microplastic contamination has been reported in numerous freshwater fish species worldwide, demonstrating that fish readily ingest plastic particles from contaminated water, sediments, and food organisms. Both field investigations and laboratory studies have confirmed the presence of MPs in the gastrointestinal tract, gills, liver, kidneys, and, in some cases, muscle tissues of freshwater fish [5].

The extent of microplastic ingestion varies depending on species, feeding behavior, habitat preference, age, environmental conditions, and local pollution levels. Omnivorous and benthic-feeding fish generally exhibit higher levels of contamination because they consume both suspended particles and sediment-associated food items. Several studies have identified fibers and fragments as the most frequently detected microplastic forms in freshwater fish [11].

Among freshwater species, *Labeo rohita* is considered a suitable bioindicator of microplastic pollution because of its ecological importance, omnivorous feeding habit, widespread distribution, and high commercial value. However, information regarding microplastic contamination in *L. rohita*, particularly from Pakistan, remains limited. Expanding research on this species is essential for understanding contamination pathways, ecological risks, and potential food safety concerns associated with human fish consumption [15].

8. Biological Effects of Microplastics on Fish

Microplastic exposure adversely affects the physiological, biochemical, and reproductive health of freshwater fish. After ingestion, MPs accumulate primarily in the gastrointestinal tract but may subsequently translocate to other organs, including the gills, liver, kidneys, and reproductive tissues. In addition to causing physical injury, microplastics induce oxidative stress, inflammation, immune dysfunction, endocrine disruption, and alterations in gene expression [1].

The severity of toxic effects depends on several factors, including particle size, concentration, polymer type, exposure duration, and the presence of adsorbed environmental contaminants. Continuous exposure may impair fish growth, metabolism, survival, and reproductive performance, ultimately affecting aquatic biodiversity and ecosystem stability [8].

6.1 Effects on Gills

The gills are among the first organs exposed to microplastics suspended in water. Adherence of MPs to the gill surface may increase mucus secretion, reduce respiratory efficiency, and impair normal gas exchange. Prolonged exposure can cause epithelial damage, inflammation, oxidative stress, and disturbances in ion regulation, thereby compromising overall respiratory function and physiological homeostasis [4].

6.2 Effects on the Gastrointestinal Tract

The gastrointestinal tract is the primary site of microplastic accumulation in freshwater fish. Ingested particles may cause intestinal blockage, epithelial abrasion, inflammation, and reduced nutrient absorption. Microplastics can also alter gut microbiota and increase oxidative stress, leading to impaired digestive efficiency and reduced growth performance during prolonged exposure [15].

6.3 Effects on the Kidneys

Although kidneys are not directly exposed to environmental microplastics, translocation of small particles through the circulatory system may result in renal accumulation. Experimental studies have reported histopathological alterations, impaired filtration capacity, oxidative stress, and disruption of osmoregulatory functions following chronic microplastic exposure. These effects may reduce the ability of fish to maintain normal physiological balance [13].

6.4 Effects on the Immune and Reproductive Systems

Microplastics have been shown to interfere with immune function by inducing chronic inflammation, oxidative stress, and altered expression of immune-related genes. Continuous exposure may suppress immune responses, increasing susceptibility to infectious diseases as shown in Fig. 3.

Reproductive toxicity is another significant consequence of microplastic exposure. Studies have demonstrated adverse effects on gonadal development, gamete quality, fertilization success, embryonic development, and reproductive hormone regulation. In severe cases, prolonged exposure may reduce reproductive capacity and negatively influence fish population sustainability [1].

Fig.3: Effect of MP's on Fish Health

9. Labeo rohita: A Bioindicator of Freshwater Microplastic Pollution

9.1 Taxonomic Classification

Labeo rohita (Rohu) is one of the most economically important freshwater fish species belonging to the family Cyprinidae. It is widely cultured and naturally distributed throughout South Asia, particularly in Pakistan, India, Bangladesh, and Nepal. Because of its ecological significance, commercial value, and widespread human consumption, L. rohita is frequently used as a representative species in environmental and toxicological studies [1].

Taxonomical Classification

- Kingdom: Animalia
- Phylum: Chordata
- Subphylum: Vertebrata
- Class: Actinopterygii
- Order: Cypriniformes
- Family: Cyprinidae
- Genus: Labeo
- Species: Labeo rohita

9.2. Morphology

Labeo rohita possesses a moderately elongated and laterally compressed body covered with cycloid scales. The head is relatively small with a blunt snout, and the mouth is subterminal, adapted for feeding within the water column. The body is silvery with a bluish-grey dorsal surface, while the fins often exhibit a reddish or orange coloration. Adults may attain a length exceeding one meter under favorable environmental conditions. Its streamlined body and omnivorous feeding adaptations enable efficient utilization of diverse freshwater habitats [6].

7.3 Habitat and Biology

Labeo rohita naturally inhabits rivers, lakes, reservoirs, floodplains, and ponds characterized by slow to moderately flowing freshwater. It is widely distributed throughout the Indus, Ganges, Brahmaputra, and associated river systems. Rohu generally occupies the middle water column and thrives in warm tropical and subtropical climates [3].

The species exhibits rapid growth, adapts well to aquaculture conditions, and reaches sexual maturity within approximately two to three years. Spawning usually occurs during the monsoon season when increased water flow and suitable environmental conditions stimulate reproduction. Because of its ecological adaptability and high productivity, L. rohita remains one of the principal freshwater aquaculture species in South Asia [4].

7.4 Feeding Habit

Labeo rohita is an omnivorous freshwater fish whose feeding behavior changes during different stages of development. Larvae and juveniles primarily consume zooplankton, small crustaceans, and aquatic invertebrates, whereas adults predominantly feed on phytoplankton, algae, aquatic vegetation, detritus, and other organic materials suspended within the water column [9].

Its diverse feeding strategy increases the likelihood of ingesting microplastics present in contaminated water, sediments, and food organisms. Consequently, L. rohita serves as an excellent model species for evaluating microplastic exposure and trophic transfer in freshwater ecosystems [2].

7.5 Importance of Labeo rohita

Labeo rohita is one of the most valuable freshwater fish species in South Asia due to its ecological, nutritional, and economic significance. It contributes substantially to inland fisheries and commercial aquaculture while serving as an important source of high-quality protein for millions of people. The species also supports rural livelihoods through fish farming, marketing, and associated industries [16].

From an environmental perspective, *L. rohita* has gained increasing attention as a biological indicator of freshwater pollution. Its widespread distribution, omnivorous feeding behavior, continuous interaction with contaminated aquatic environments, and commercial importance make it particularly suitable for monitoring microplastic contamination and evaluating associated ecological and food safety risks [5]. Selection of *Labeo rohita* is shown in Fig.4.

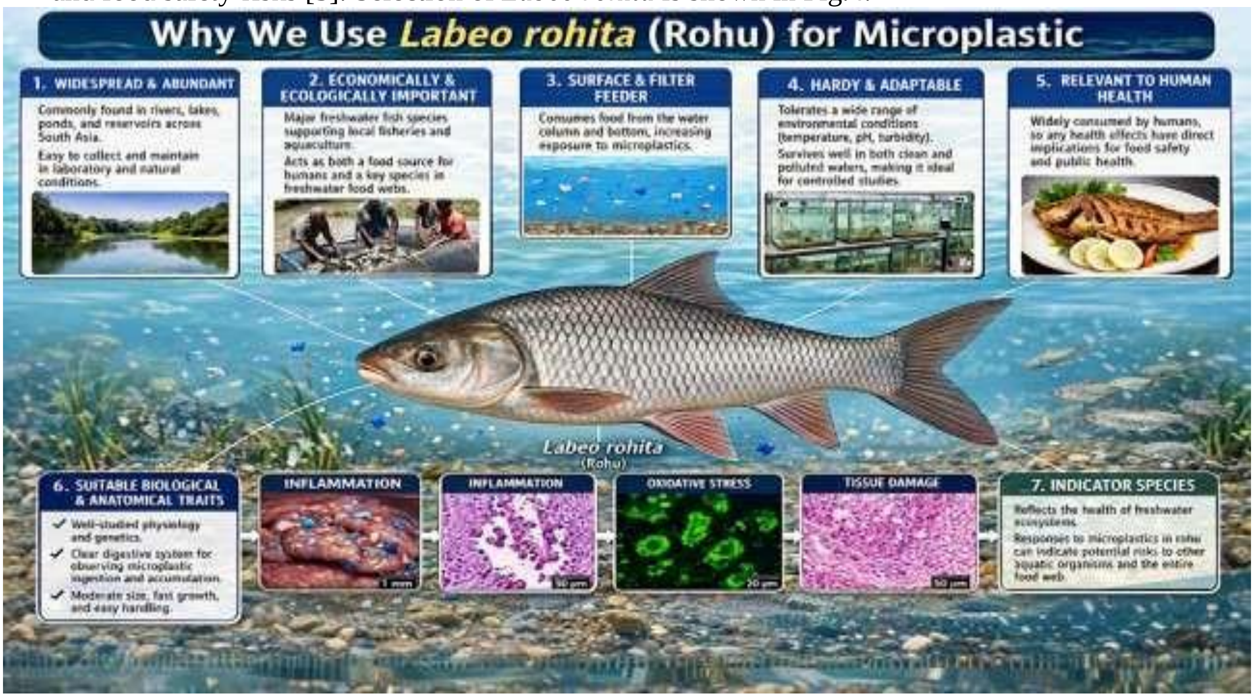

Fig. 4: Selection of *Labeo rohita*

8. Food Safety Implications

Microplastic contamination in freshwater fish has emerged as an important food safety concern because fish constitute a major source of dietary protein worldwide. Humans may be exposed to microplastics through the consumption of contaminated fish and other aquatic food products. Although the gastrointestinal tract, where most microplastics accumulate, is commonly removed before consumption, several studies have reported the presence of microplastics in edible tissues under certain exposure conditions, highlighting the need for further investigation [1].

In addition to the plastic particles themselves, microplastics can transport toxic substances such as heavy metals, pesticides, antibiotics, and persistent organic pollutants. These contaminants may accumulate within aquatic organisms and undergo trophic transfer through the food chain, potentially increasing risks to human health. While the long-term consequences of dietary microplastic exposure remain incompletely understood, growing evidence suggests possible associations with oxidative stress, inflammation, endocrine disruption, and metabolic disturbances.

Considering the high consumption of *Labeo rohita* across South Asia, continuous monitoring of microplastic contamination is essential to safeguard consumer health and ensure the safety of freshwater fish products [9].

9. Future Perspectives

Although considerable progress has been made in understanding microplastic pollution, significant knowledge gaps remain regarding its occurrence, toxicity, and long-term ecological consequences in freshwater ecosystems. Future research should prioritize the development of standardized sampling and analytical protocols to improve the comparability of data among studies.

Greater attention should also be directed toward investigating the accumulation of microplastics in edible fish tissues, the role of nanoplastics, mechanisms of trophic transfer, and interactions between microplastics and other environmental contaminants. In developing countries, including Pakistan, comprehensive monitoring programs are urgently needed to evaluate regional contamination levels and identify major pollution sources [1].

From a management perspective, reducing plastic waste generation, improving recycling infrastructure, strengthening wastewater treatment technologies, and implementing effective environmental policies are essential for minimizing microplastic release into freshwater ecosystems. Public awareness campaigns and sustainable alternatives to single-use plastics will further contribute to protecting aquatic biodiversity and food security [10].

10. Conclusion

Microplastic pollution has become an emerging environmental challenge with significant implications for freshwater ecosystems, aquatic biodiversity, and human health. Freshwater environments receive microplastics from multiple anthropogenic sources, including domestic wastewater, industrial effluents, agricultural runoff, atmospheric deposition, and the degradation of larger plastic materials. Once released into aquatic ecosystems, these particles are readily ingested by freshwater organisms, resulting in their accumulation within various tissues and organs.

Exposure to microplastics has been associated with numerous adverse biological effects, including oxidative stress, tissue damage, impaired nutrient absorption, immune dysfunction, reproductive toxicity, and behavioral alterations. Owing to its ecological importance, widespread distribution, omnivorous feeding behavior, and high commercial value, *Labeo rohita* serves as an effective bioindicator for assessing freshwater microplastic contamination and evaluating associated food safety risks. Despite increasing scientific attention, information regarding microplastic contamination in freshwater fish remains limited in many developing countries, including Pakistan. Therefore, comprehensive environmental monitoring, standardized research methodologies, improved plastic waste management, and evidence-based policy interventions are essential for mitigating microplastic pollution and protecting freshwater ecosystems. Continued scientific investigation will be crucial for understanding the long-term ecological and public health consequences of microplastic exposure while supporting sustainable management of aquatic resources.

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