

Microplastics and Heavy Metals Contamination in *Clarias gariepinus* from Eleyele Reservoir, Nigeria, During Rainy Season: A Public Health Concern

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Abstract

Microplastics and heavy metals are co-occurring aquatic contaminants with potential implications for fish safety and human health. This study assessed microplastic and heavy metal contamination in *Clarias gariepinus* from Eleyele reservoir. Microplastics were extracted from gill, liver, and muscle tissues using hydrogen peroxide digestion and characterized by Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy, while heavy metals were quantified using atomic absorption spectrometry. A total of 490 microplastic particles were recovered, with mean abundances of 6.25 ± 1.09 , 3.16 ± 0.60 , and 2.23 ± 0.47 items per individual in gill, liver, and muscle, respectively. Fibers, fragments, foams, and films occurred in all tissues, with gills showing the highest abundance. Particles measuring 100-500 μm and transparent microplastics predominated, while microplastic abundance correlated positively with fish length and weight. Cadmium remained below detectable limits in all tissues. Lead concentrations ranged from 0.02 ± 0.04 mg/kg in liver to 0.60 ± 0.13 mg/kg in muscle, exceeding the permissible limit in muscle. Chromium increased from gill (0.39 ± 0.04 mg/kg) to liver (1.17 ± 0.05 mg/kg) and muscle (2.64 ± 0.70 mg/kg), while nickel concentrations were elevated in all tissues (6.83-10.34 mg/kg). Zinc was the most abundant metal but remained within guideline limits. Hazard quotient values indicated no risk from muscle consumption; however, nickel in the gill and chromium and nickel in the liver exceeded safe thresholds. Carcinogenic risk values for lead and chromium exceeded acceptable limits, indicating potential long-term public health concerns from regular fish consumption.

Categories: Food security and sustainability, Food toxicology, Fishery ecology

Keywords: pollutants, fish safety, trophic transfer, food security, human population

Introduction

Aquatic environments worldwide are increasingly threatened by pollution arising from industrial discharges, agricultural runoff, domestic wastewater, and urban activities. These contaminants degrade aquatic habitats, disrupt ecosystem functioning, and pose serious risks to aquatic organisms and human populations that depend on these resources [1]. Environmental pollution has therefore become a major global concern, causing significant alterations in natural ecosystems and threatening biodiversity and public health [2]. Among the numerous contaminants affecting aquatic ecosystems, heavy metals and microplastics are regarded as some of the most persistent and hazardous pollutants.

Heavy metals enter aquatic environments through both natural processes and anthropogenic activities, such as industrial operations, agriculture, and domestic effluents [3], where they accumulate in sediments and can subsequently be taken up by aquatic organisms. Fish are particularly vulnerable because they can bioaccumulate metals within their tissues and

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are therefore widely used as biomonitors of ecosystem health [4-7]. Heavy metals are broadly categorized into essential elements such as zinc, copper, iron, and manganese, which are necessary for metabolic processes but become toxic at elevated concentrations, and non-essential elements, such as cadmium, lead, mercury, arsenic, and chromium, which are highly toxic and have no known biological function [8]. Elevated concentrations of these contaminants may cause structural tissue damage, disrupt physiological and neurological processes, and impair growth in aquatic organisms [9-10], while also posing serious health risks to humans through biomagnification along the food chain [11].

In addition to heavy metal pollution, microplastics have emerged as a major environmental concern in aquatic ecosystems. Plastics are among the most widely produced materials globally because of their durability, low cost, and versatility; however, these same properties contribute to their persistence in the environment [12]. It is estimated that approximately 8 million metric tons of plastic enter the oceans annually, with plastic debris now widely distributed across marine, freshwater, and terrestrial ecosystems [13-14]. Through physical, chemical, and biological degradation processes, larger plastic materials gradually fragment into smaller particles known as microplastics, generally defined as plastic particles smaller than 5 mm [15]. Microplastics may occur as either primary microplastics intentionally manufactured at microscopic sizes or secondary microplastics generated by the breakdown of larger plastic debris [16].

Due to their small size and low density, microplastics are readily dispersed within aquatic systems, where they accumulate in both the water column and sediments [17-18]. Freshwater bodies such as rivers and lakes often serve as transport pathways and accumulation zones for microplastics, especially in urbanized regions with inadequate waste management practices [19]. Microplastics are increasingly recognized as widespread contaminants in freshwater environments, posing potential threats to aquatic ecosystems. Several studies have documented the ingestion of microplastics by aquatic organisms, including fish and other aquatic fauna [20-21].

The distribution and abundance of microplastics in freshwater ecosystems are strongly influenced by seasonal hydrological conditions. During the rainy season, increased precipitation, surface runoff, erosion, stormwater discharge, and watershed inflows facilitate the transport of plastic debris from terrestrial environments into rivers, lakes, and reservoirs. Consequently, freshwater bodies often experience elevated microplastic loads during periods of intense rainfall, particularly in urbanized catchments where inadequate waste management practices promote the mobilization of plastic waste. Seasonal runoff can also enhance the transfer of associated contaminants, including heavy metals, into aquatic environments. Therefore, investigations conducted during the peak rainy season provide valuable insights into periods of potentially heightened contaminant exposure for aquatic organisms. In southwestern Nigeria, the months of June to September coincide with the peak rainy season and are characterized by increased runoff into freshwater systems, making this period particularly relevant for assessing microplastic contamination and associated ecological risks.

The presence of microplastics in aquatic environments is of particular concern because of their persistence and their potential impacts on ecosystem integrity and human health [22]. In fish, microplastic ingestion has been associated with adverse effects including reduced feeding efficiency, impaired growth and development, endocrine disruption, oxidative stress, and tissue damage [23]. Moreover, microplastics can act as vectors for environmental contaminants because their surfaces readily adsorb hazardous substances such as heavy metals, persistent organic pollutants, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls [24-25]. Previous studies have demonstrated the strong adsorption capacity of microplastics for a wide range of chemical pollutants [26-28]. These contaminants may subsequently desorb within biological tissues and contribute to endocrine disruption, oxidative stress, cytotoxic effects, and other physiological impairments [29-30]. The interaction between microplastics and heavy metals may also result in synergistic or antagonistic toxic effects, thereby complicating the assessment of environmental risks [31-33].

Although the long-term health implications of microplastic ingestion are still being investigated, emerging evidence suggests that microplastics may cross intestinal barriers and enter systemic circulation through mechanisms such as persorption and endocytosis [34]. The detection of plastic particles in human blood samples further supports the possibility of systemic exposure [35]. Once internalized, microplastics may induce oxidative stress, inflammatory responses, and cellular damage [36]. The occurrence of microplastics in edible fish species, therefore, raises important food safety concerns [37].

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Fish constitute an important source of dietary protein for human populations worldwide. Global fish consumption has increased substantially, rising from about 9.0 kg per capita in 1961 to more than 20 kg per capita in recent years, largely due to population growth, rising incomes, and the expansion of aquaculture [38]. However, because fish often occupy higher trophic levels in aquatic food webs, they are capable of accumulating environmental contaminants in their tissues [39]. Consequently, fish are widely used as sentinel organisms and bioindicators of aquatic pollution, helping scientists evaluate ecological risks and potential human health implications [40].

Clarias gariepinus, commonly known as the African sharp-tooth catfish, is widely distributed across Africa and possesses several morphological and physiological adaptations that enable it to survive in diverse and often challenging environments, including an elongated body, sensory barbels for feeding in turbid waters, and accessory air-breathing organs that allow it to tolerate hypoxic conditions [41-42]. Due to its rapid growth rate, high fecundity, disease resistance, and tolerance to a wide range of environmental conditions, this species has become one of the most commonly cultured and consumed fish species in Africa, particularly in Nigeria [43]. As an opportunistic benthic feeder, it consumes insects, crustaceans, and detritus, a feeding habit that increases its likelihood of encountering and ingesting sediment-associated contaminants such as heavy metals and microplastics.

Eleyele Reservoir, Nigeria, is an important freshwater body that supports artisanal fisheries and provides fish for local consumption [44]. A recent study reported the occurrence of microplastics in the reservoir [45]. However, information regarding the tissue-specific distribution of microplastics in fish from this water body remains limited, and data on the co-occurrence of heavy metals and microplastics in the reservoir's biota are lacking. In particular, information on microplastic ingestion by fish inhabiting Eleyele Reservoir remains scarce. Given that the present study was conducted during the peak rainy season (June-September), when contaminant inputs through runoff are expected to be elevated, it provides important baseline information on microplastic occurrence and heavy metal contamination under conditions of heightened environmental exposure.

Considering the trophic linkage between fish and humans, the occurrence of microplastics and heavy metals in edible fish species raises potential public health concerns. Given that *C. gariepinus* represents a major protein source for residents of Ibadan and surrounding communities, understanding the levels and distribution of these contaminants in this species is essential for evaluating possible health risks. Therefore, this study investigates the abundance and characteristics of microplastics, along with the concentrations of heavy metals, in frequently consumed freshwater *C. gariepinus* from Eleyele Reservoir. In addition, the research evaluates the human health risks associated with the consumption of *C. gariepinus* due to heavy metal exposure.

Materials And Methods

Description of the study location

Eleyele reservoir lies at 125 m above sea level (latitude 7°25'-7°26'N, longitude 3°51'-3°52'E). It has a maximum depth of 12 m, an impoundment area of 5.46 km², and a storage capacity increased from 704 to 900 million liters to meet domestic water demand. Originally built for domestic water supply, Eleyele Lake now supports fishing, irrigation, and recreation, contributing to local livelihoods. The reservoir receives inflow from rivers, residential wastewater, and effluents from small-scale agro-processing. The reservoir faces significant anthropogenic pressures that may influence water quality and pollutant accumulation in aquatic organisms.

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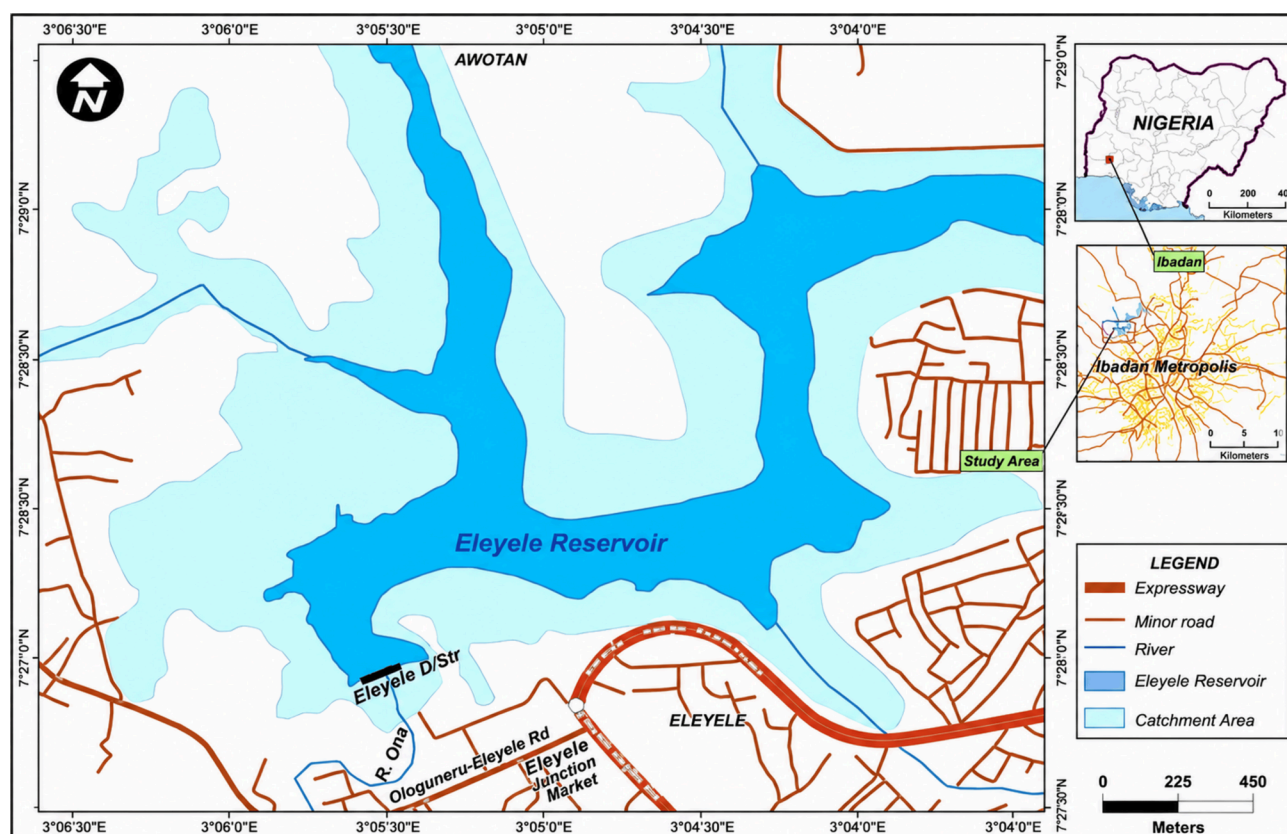


FIGURE 1: Map of Eleyele reservoir.

Source: Olanrewaju et al. [44].

Sample collection

A total of 80 *C. gariepinus* were collected biweekly over a period of 4 months (June to September) corresponding to the peak rainy season in southwestern Nigeria from local fishermen operating in Eleyele reservoir using a gillnet (ranged from 25 mm to 75 mm) and castnet (20 mm). This period was selected because increased rainfall and runoff are known to enhance the transport of plastic debris and associated contaminants into freshwater ecosystems. Immediately after collection, the samples were placed in ice packs to maintain freshness and transported to the laboratory. In the laboratory, each specimen was carefully dissected to obtain the muscle, gill, and liver tissues. The collected tissues were then preserved and stored at 4°C until further analysis.

Heavy metal analysis

Twenty samples of *C. gariepinus* ($n = 20$) were used for heavy metal analysis. Liver ($n = 20$), gill ($n = 20$), and muscle tissues ($n = 20$) were dissected from each fish (total number of organs = 60), oven-dried, homogenized by crushing, and accurately weighed (0.5 g) using an electronic balance [46]. Each weighed sample was transferred into a 100 mL beaker for digestion. A tri-acid digestion mixture consisting of nitric acid (HNO_3 , 69%), sulfuric acid (H_2SO_4 , 98%), and perchloric acid (HClO_4 , 70%) in a 5:1:1 ratio was used [47]. During digestion, all conical flasks containing samples were covered with watch glasses to minimize contamination and prevent the loss of volatile elements. After digestion, the solutions were allowed to cool to room temperature and then filtered through Whatman No. 42 filter paper pre-rinsed with 0.1 M HNO_3 . The filtrates were subsequently diluted to a final volume of 50 mL using double-distilled water [48]. Metal concentrations

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were then determined using Atomic Absorption Spectrometry (Model AA-7000, SHIMADZU, Japan). All reagents used were of analytical grade (Merck, Germany), and double-distilled water was used throughout the procedure to ensure analytical accuracy and avoid contamination.

Microplastic extraction from fish species

A total of 60 *C. gariepinus* individuals were processed for microplastic isolation. Each specimen was placed in a 100 mL beaker and subjected to chemical digestion using a hydrogen peroxide (H₂O₂) protocol with slight modifications [49,50]. Briefly, digestion was carried out by adding 10 mL of H₂O₂ and 10 mL of 0.05 M Fe (II) solution, after which the samples were incubated at 40°C for 72 hours. Where visible organic residues persisted, an additional 5 mL of H₂O₂ was introduced and the digestion process was continued until complete breakdown of organic material was achieved. Following digestion, the resulting solution was filtered through Whatman GF/B filter paper using a vacuum filtration system. The filter papers were then transferred into clean glass Petri dishes, air-dried, sealed, and wrapped with aluminum foil to prevent contamination before subsequent analysis.

Identification and characterization of microplastics

All filter papers were examined visually using a HumaScope Advanced LED binocular microscope (Human, Germany), with magnification adjusted between 10× and 100× for detailed observation. In addition, captured images were further processed and analyzed using ImageJ software. Each microplastic particle was identified visually and recorded based on total abundance, color, morphology, and size classes [51]. A hot-needle test was also conducted to assist in confirming suspected microplastic particles. For chemical identification and polymer characterization, Fourier Transform Infrared Spectroscopy (FTIR) analysis was performed using an FTIR-4600 spectrometer equipped with an Attenuated Total Reflection (ATR) accessory. Spectra were recorded within the 500-4000 cm⁻¹ range at a resolution of 4 cm⁻¹. Data acquisition was carried out using SpectraManager™ II software, while spectral matching and polymer identification were conducted using the KnowItAll® software and its associated commercial spectral libraries.

Quality control for microplastic and heavy metals

All reagents and deionized water were pre-filtered using GF/B Whatman filters (1 µm pore size, 47 mm diameter) and stored in glass containers before analysis to minimize contamination during laboratory procedures. All glassware and laboratory equipment were thoroughly cleaned and air-dried before use. Sample preparation was conducted inside a clean, enclosed fume hood, and aluminum foil was used to cover materials in order to limit contamination from airborne microplastics. A procedural blank, containing no fish tissue, was processed alongside the samples following the same analytical steps used for microplastic and heavy metal determination to account for any contamination introduced during analysis. To further reduce contamination risks, laboratory personnel wore cotton lab coats and latex gloves throughout the experimental procedures. In addition, all samples were rinsed thoroughly with filtered deionized water before preparation for analysis.

Rigorous quality assurance and quality control procedures were implemented throughout the analytical process to ensure the accuracy and reliability of heavy metal determinations in *C. gariepinus* tissue/organ samples. Reagent blanks containing only the digestion acids were prepared and analyzed alongside the samples to monitor potential contamination during digestion and instrumental analysis. Method accuracy was verified using certified reference materials (CRMs) appropriate for fish tissue analysis. In addition, recovery studies were conducted by spiking selected samples with known concentrations of cadmium, lead, chromium, nickel, and zinc to evaluate the efficiency of the digestion procedure and analytical performance. Heavy metal concentrations were quantified using an Atomic Absorption Spectrophotometer (Model AA-7000, SHIMADZU, Japan). Calibration was performed with certified standard solutions, and calibration curves were established for each metal. The coefficients of determination (*R*²) for all calibration curves exceeded 0.99, demonstrating excellent linearity of the analytical method. These procedures ensured the generation of accurate, precise, and reproducible heavy metal data for the fish tissue samples analyzed in this study.

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Potential risk assessment of microplastics

Potential hazard of microplastics can be widely estimated using the Polymer Hazard Index (PHI) [52]. This method evaluates the overall risk of microplastics by combining the relative abundance of each polymer type with its corresponding toxicity score.

The PHI was calculated using the following equation: $PHI = \sum (P_n \times S_n)$

where PHI represents the polymer hazard index of the detected microplastics, P_n refers to the percentage contribution of each polymer type among the identified microplastics, and S_n represents the hazard score assigned to each polymer type. Based on the calculated PHI values, the hazard level of microplastic contamination can be categorized into different risk classes, as described in previous studies [53-54]. The PHI values are classified into five categories with corresponding hazard and risk levels. A PHI of 0-1 falls under Hazard Category I and is considered a Minor risk. Values between 1 and 10 belong to Hazard Category II, indicating Medium risk. A PHI of 10-100 is placed in Hazard Category III, which signifies a High risk. PHI values from 100 to 1000 fall into Hazard Category IV, classified as Danger. Finally, any PHI exceeding 1000 falls under Hazard Category V, representing an Extreme danger.

Health risk assessment of heavy metals in *C. gariepinus*

The assessment of health risks from heavy metals in *C. gariepinus* was conducted by calculating the Estimated Daily Dietary Intake (EDI) and Hazard Quotient (HQ) [55].

The EDI is computed as follows: $EDI = (C \times IR)/BW$

EDI is the estimated daily intake of heavy metals through diet (mg/kg/day), C represents the concentration of heavy metals in fish tissue (mg/kg), and IR is the daily ingestion rate of seafood and canned fish products, estimated at 0.30 kg/person/day for adults and 0.15 kg/person/day for children. BW represents the average body weight, assumed to be 60 kg for adults and 25 kg for children [55-56].

The HQ, which evaluates the risk level of heavy metal exposure, is calculated by: $HQ = EDI/RfD$

RfD is the reference dose for each heavy metal [57]: Cd = 0.001, Cr = 0.003, Ni = 0.02, Pb = 0.004, and Zn = 0.3 (mg/kg/day). An HQ greater than 1 indicates a likelihood of adverse health effects, while an HQ less than 1 suggests no significant risk.

Carcinogenic risk (CR) associated with heavy metal exposure through fish consumption was calculated [58]:

$$CR = CSF \times EDI$$

where:

CSF = cancer slope factor (mg/kg/day)

EDI = estimated daily intake (mg/kg/day)

The total carcinogenic risk (TCR) was calculated as the sum of individual CR values for each metal: $TCR = \sum CR$

The cancer slope factors used are: Chromium = (0.5mg/kg/day) and Lead = (0.38mg/kg/day) [59]. CR values below 1×10^{-6} were considered negligible, values between 1×10^{-6} and 1×10^{-4} were considered within the acceptable, whereas values exceeding 1×10^{-4} indicated an unacceptable CR [57, 60].

Statistical analysis

Descriptive statistics for fish length and weight, microplastic attributes, and health risk indices were computed using Microsoft Excel. Relationships among microplastic abundance, fish body length, and weight were evaluated using linear regression analysis. For regression analyses, monthly mean values were used as data points, resulting in four X-Y observations corresponding to the four sampling months. Each monthly mean was calculated from 20 individual fish specimens ($n = 20$).

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Differences in heavy metal concentrations among tissue types were evaluated using one-way analysis of variance (ANOVA). One-way ANOVA was conducted using individual fish observations as replicates, with a total of 60 tissue samples analyzed ($n = 20$ per tissue type: liver, gill, and muscle). Before ANOVA, the assumptions of normality and homogeneity of variances were assessed using the Shapiro-Wilk test and Levene's test, respectively. Data met these assumptions and data were analyzed without transformation. Statistical significance was established at $P < 0.05$ using Python 3.13 with the following open-source libraries: SciPy (v1.11.4) for ANOVA and assumption testing, StatsModels (v0.14.1) for linear regression, and Pandas (v2.1.3) for data organization.

Results And Discussion

The present study was conducted on *C. gariepinus* collected from the Eleyele reservoir to evaluate the occurrence, distribution, and associated risks of microplastics and heavy metals across different tissues. The biometric characteristics of the fish are presented in Table 1. Standard length ranged from 25.00 to 37.00 cm, while body weight ranged from 150.23 to 380.74 g. Regarding the length, no significant differences were observed between June and July ($P < 0.05$), nor between August and September ($P < 0.05$). Conversely, the body weight of *C. gariepinus* varied significantly across all sampled months ($P < 0.05$). The FT-IR spectra (Figure 2) revealed the occurrence of five polymer types in *C. gariepinus*, namely polyamide (PA), polyethylene terephthalate (PET), polyethylene (PE), polypropylene (PP), and polystyrene (PS). Polyamide consistently showed the highest proportion across all examined tissues, whereas polystyrene was the least abundant. The predominance of PA is noteworthy because this polymer is commonly associated with fishing nets, ropes, and lines, suggesting that fishing-related activities constitute an important source of microplastic pollution within Eleyele reservoir [61]. Similar observations have been reported in several freshwater and marine environments [62].

In the gill tissue (Figure 3), PA constituted the highest proportion (24.4%), followed by PET (22.0%) and PP (20.0%), while PE and PS occurred in smaller proportions. The high accumulation observed in gills indicates that respiratory surfaces serve as major routes of exposure to suspended microplastics. Gills are continuously exposed to waterborne particles during respiration, increasing the likelihood of particle entrapment within gill filaments and lamellae. Similar findings have been reported in fish species from Jakarta Bay, where gill tissues showed elevated microplastic burdens [63]. The accumulation of microplastics in gills may impair respiratory efficiency and induce inflammatory responses [64]. Similarly, in the liver tissue (Figure 4), PA remained the dominant polymer (24.9%), followed by PET (22.4%) and PP (19.7%), while PE and PS accounted for lower proportions. The presence of microplastics in liver tissues suggests secondary accumulation following uptake through gills or the gastrointestinal tract. Experimental studies have demonstrated that smaller microplastic particles can translocate into systemic circulation and accumulate in internal organs such as the liver [65]. Given the liver's role in detoxification and metabolism, the occurrence of microplastics in hepatic tissues raises concerns regarding oxidative stress and potential toxicological effects [66]. In the muscle tissue (Figure 5), the polymer distribution pattern remained similar to that observed in gill and liver tissues, with PA recording the highest proportion (25.2%), followed by PET (23.2%) and PP (19.4%). PE accounted for 17.2%, while PS was the least represented (14.9%). Muscle tissues contained lower microplastic loads than gill and liver tissues, indicating limited translocation into edible tissues. Similar tissue-specific patterns have been documented in other fish species, where gills and internal organs contain significantly higher microplastic concentrations than muscles [67]. However, the detection of microplastics in edible tissues remains a potential pathway for human exposure through fish consumption.

The significantly higher abundance of microplastics observed in the gills compared with the liver and muscle tissues may be attributed to the gills' direct, continuous contact with the surrounding water [68]. Fish gills possess a large surface area and are continuously ventilated to facilitate gas exchange, thereby increasing the likelihood of trapping suspended microplastic particles from the aquatic environment [69]. Consequently, gills often serve as a primary site of microplastic accumulation, particularly in freshwater systems where particles remain suspended in the water column [70-71]. In contrast, accumulation within internal organs such as the liver requires translocation of particles across epithelial barriers and subsequent transport through the circulatory system, a process that is generally less efficient and dependent on

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particle size and physicochemical characteristics. The low abundance observed in muscle tissue is consistent with previous study reporting limited migration of microplastics into edible tissues compared with organs directly exposed to environmental media [72].

A linear positive relationship was observed between microplastic abundance and fish length (Figure 6) as well as fish weight (Figure 7). This relationship suggests that larger and heavier fish accumulated greater numbers of microplastics, likely due to prolonged exposure time, increased feeding activity, and higher filtration rates. Similar positive correlations between fish size and microplastic abundance have been reported in previous study [21]. The positive relationships between microplastic abundance and fish length and weight suggest that larger individuals experience greater cumulative exposure to microplastics over time [21]. Larger fish are generally older and have had longer periods to ingest or encounter microplastic particles, leading to progressive accumulation. Similar positive associations between fish size and microplastic burden have been reported in freshwater fishes and have been attributed to prolonged exposure duration, increased feeding activity, and bioaccumulation processes [73]. These findings indicate that both physiological characteristics and ecological traits influence microplastic accumulation in *C. gariepinus* and may increase contaminant burdens in larger individuals.

Month	Length (cm)		Weight (g)	
	Range	Mean ± SD	Range	Mean ± SD
June	25.00–32.50	28.73 ± 2.41 ^a	150.23–280.45	215.33 ± 10.21 ^a
July	26.50–34.00	30.18 ± 2.48 ^a	170.15–310.68	240.67 ± 13.14 ^b
August	28.00–35.50	31.82 ± 2.57 ^b	195.42–345.89	270.42 ± 16.87 ^c
September	29.50–37.00	33.29 ± 2.69 ^b	220.37–380.74	300.58 ± 20.03 ^d

TABLE 1: Length and weight of *C. gariepinus* collected from Eleyele reservoir.

Mean with the same superscripts along the columns are not significantly different at $P > 0.05$

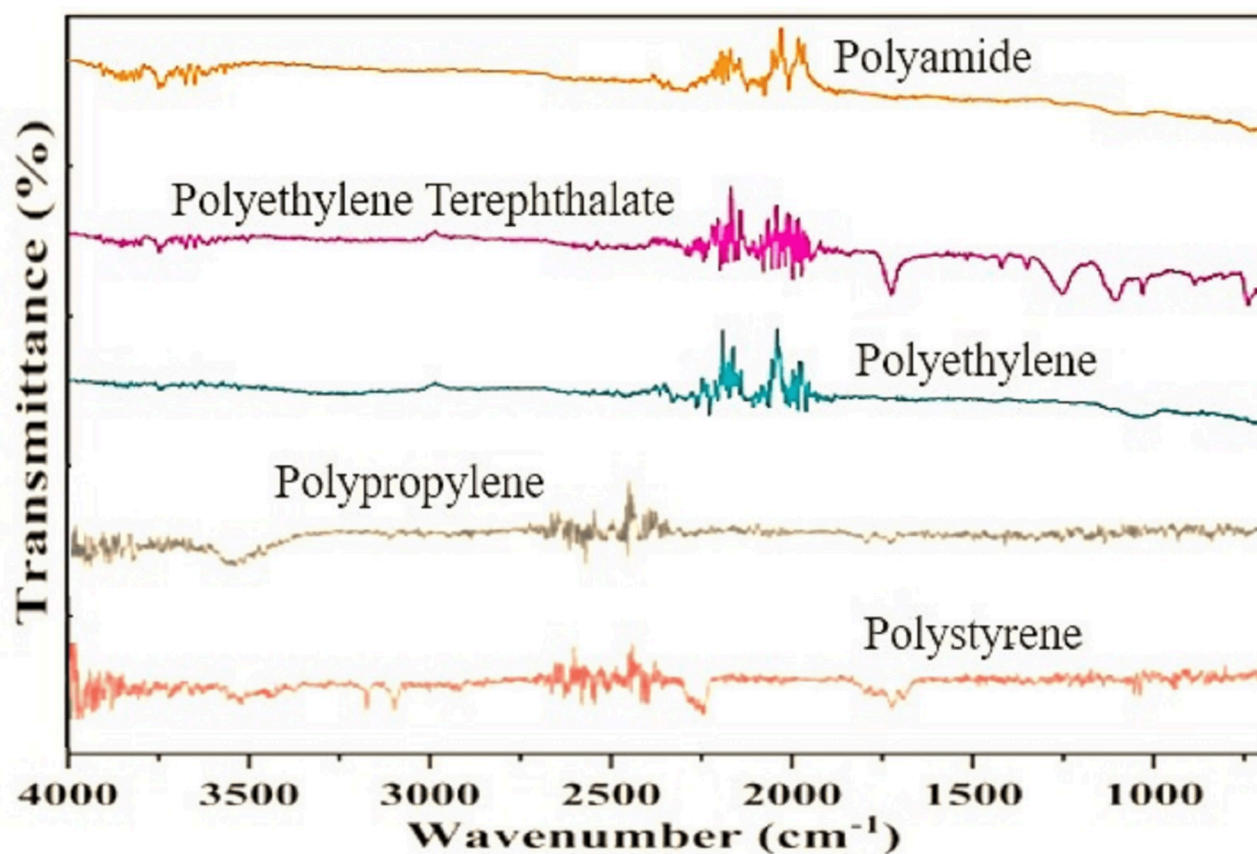


FIGURE 2: FTIR spectra of microplastic polymer found in *C. gariepinus*.

FTIR, Fourier Transform Infrared spectroscopy

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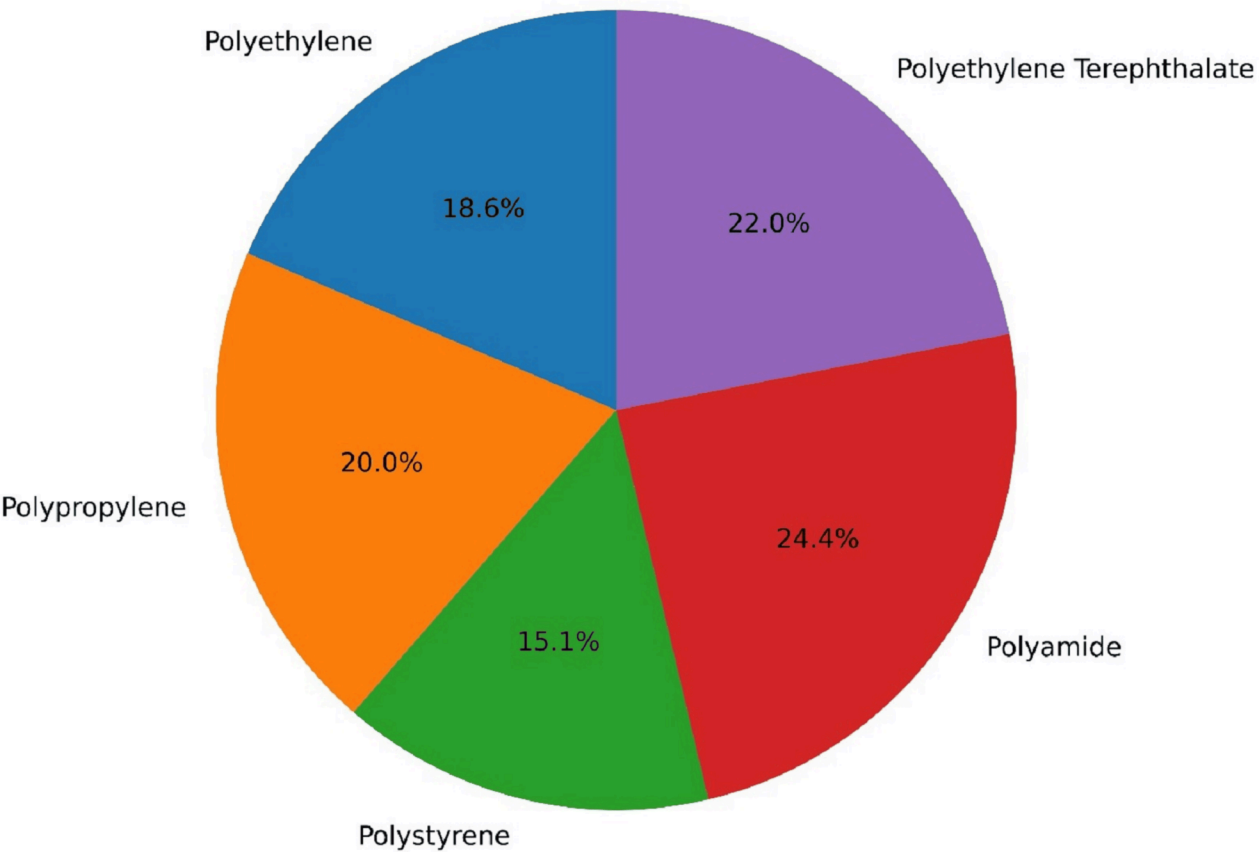


FIGURE 3: Percentage of polymer in the gill.

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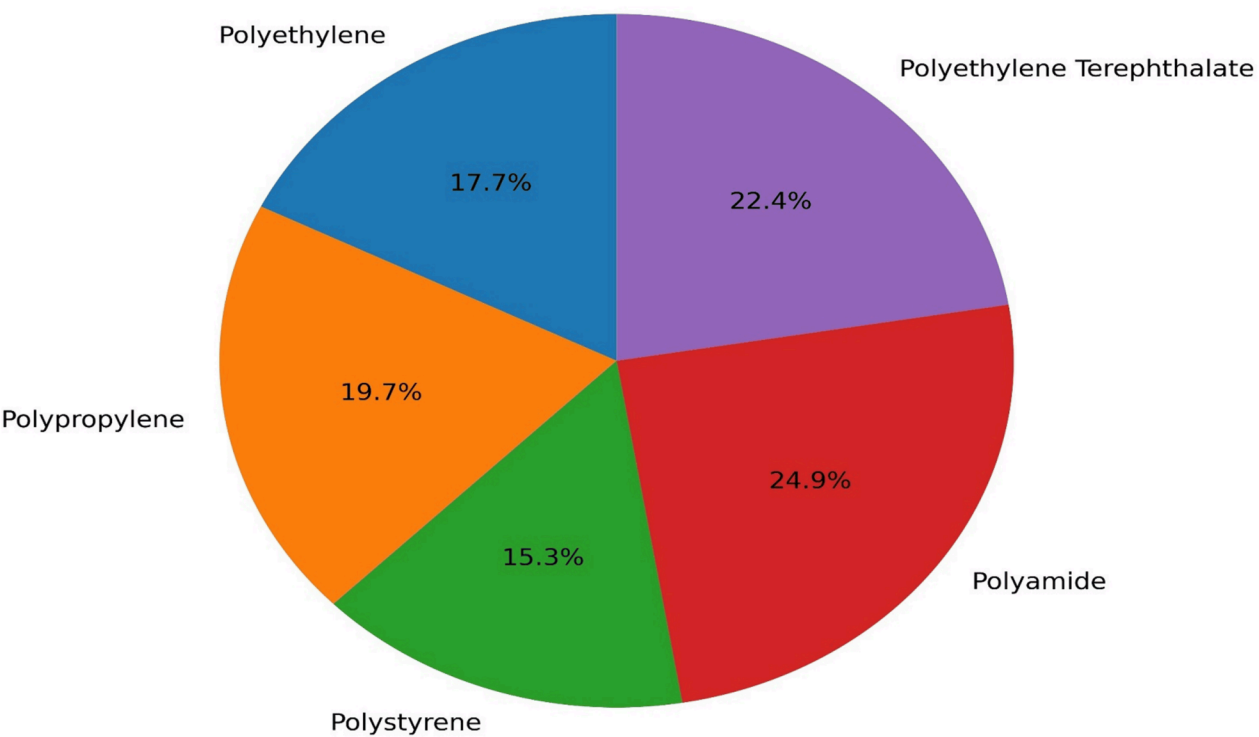


FIGURE 4: Percentage of polymer in the liver.

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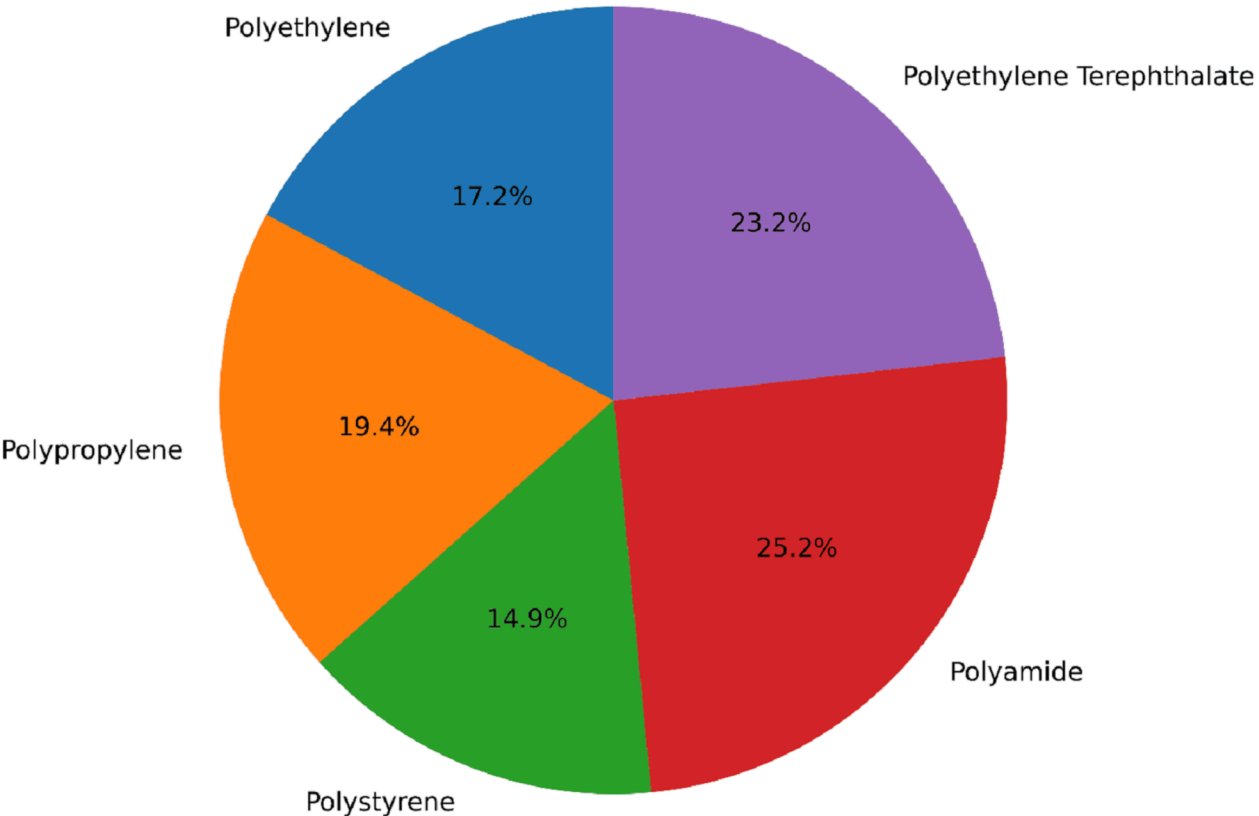


FIGURE 5: Percentage of polymer in the muscle.

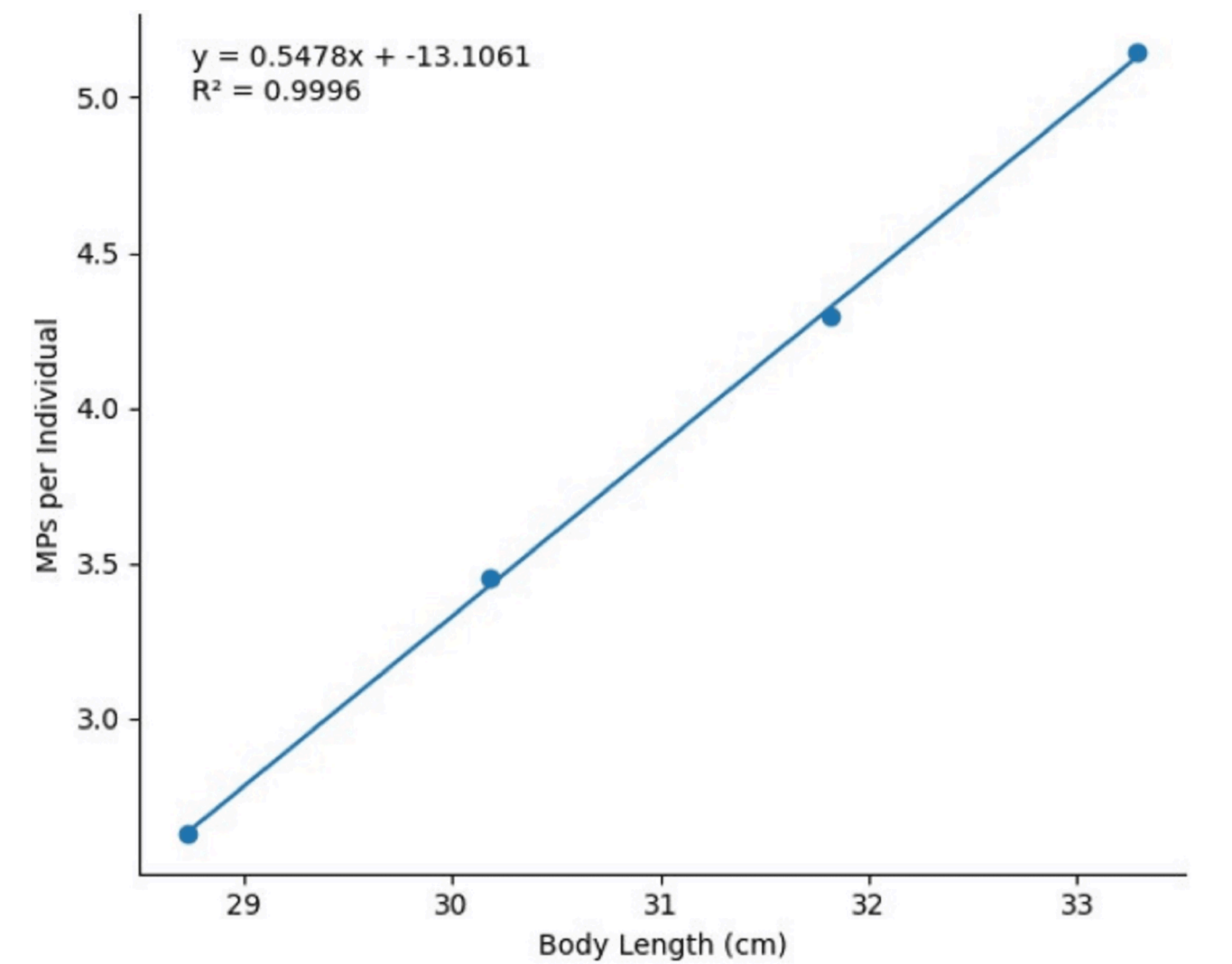


FIGURE 6: Relationship between length and microplastics abundance.

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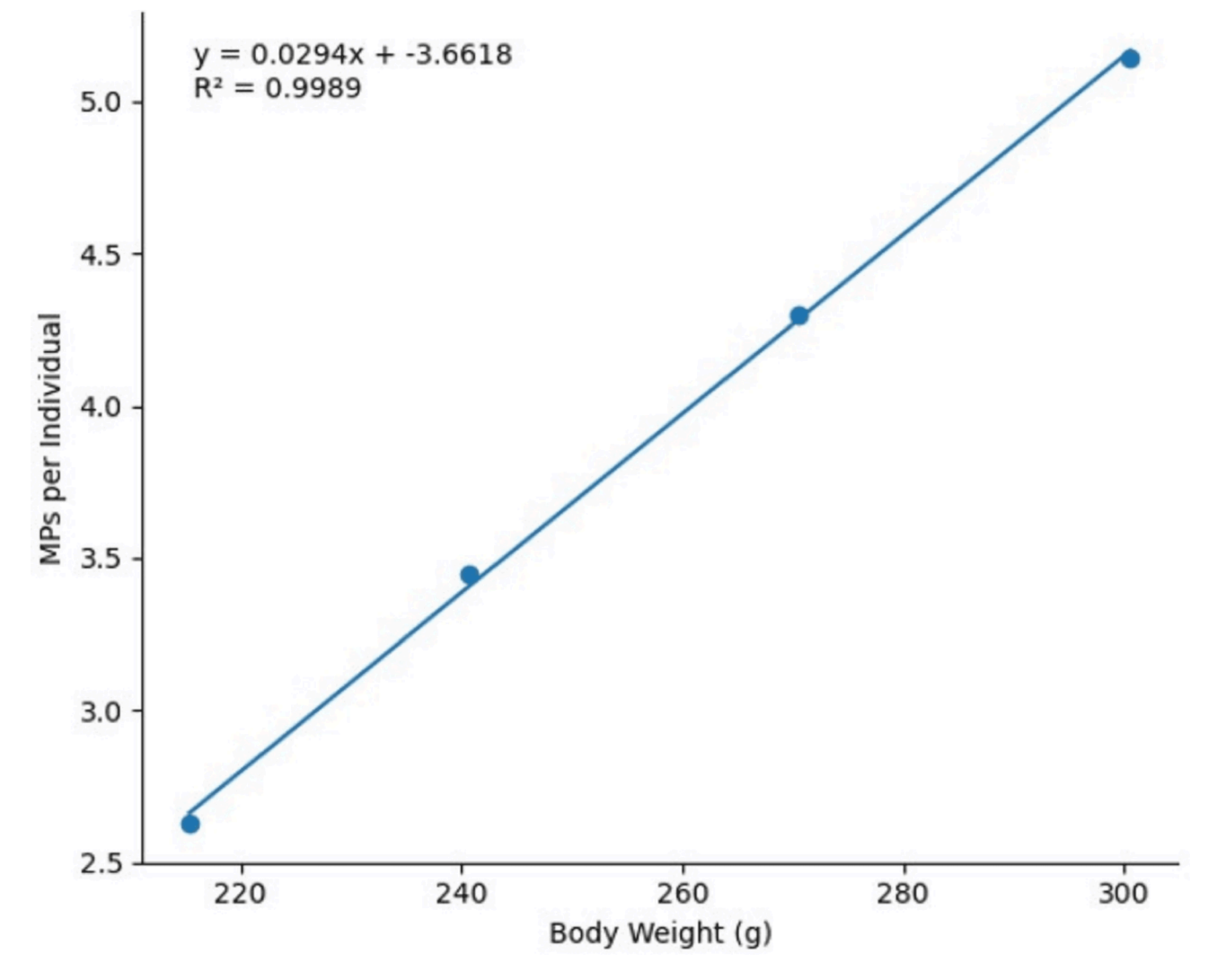


FIGURE 7: Relationship between weight and microplastics abundance.

The distribution of microplastic shapes across tissues of *C. gariepinus* is presented in Figure 8. The gills consistently contained the highest proportions of all identified particle shapes, including fibers, fragments, films, and foam. Fiber-shaped microplastics accounted for 50% of particles in the gills, followed by fragments (49%), films (52%), and foam particles (55%). The predominance of fibers agrees with several previous studies reporting fiber-rich microplastic contamination in aquatic organisms [74-75]. Fibers are commonly generated from the degradation of fishing gear, synthetic textiles, and domestic wastewater discharges [62]. Their elongated morphology facilitates entrapment within gill structures during respiration. Among fish samples from inland rivers across Nigeria's six geopolitical zones, fibers constituted the highest proportion of microplastics (48.47%), followed by fragments (29.15%) and films (22.37%) [76], a finding that corroborates the present study.

Fragments represented the second most abundant microplastic shape and are generally produced through the weathering and breakdown of larger plastic debris [77]. Foam and film particles occurred in lower proportions, suggesting additional inputs from packaging materials and consumer plastics. In the liver, fragments (30%) and fibers (29%) were more dominant, while muscle tissues recorded the lowest proportions for all particle shapes, ranging from 17% (foam) to 23% (film). The comparatively lower accumulation in muscle supports the view that most microplastics remain localized within tissues directly associated with uptake and physiological processing.

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Particle size distribution (Figure 9) revealed that particles within the 100-500 µm range were the most abundant across all tissues, particularly in muscle (40%), liver (35%), and gill (30%). The dominance of smaller particles is important because particle size strongly influences uptake and translocation within organisms. Smaller particles are more capable of penetrating epithelial tissues and entering systemic circulation [65]. Recent studies have similarly reported the predominance of particles below 500 µm in aquatic organisms and even human tissues [78]. Larger particles were less abundant, indicating reduced retention and limited internal translocation.

Color distribution analysis (Figure 10) showed that transparent microplastics were the most abundant across all tissues, followed by blue, black, red, green, and yellow particles. The predominance of transparent and blue particles may be associated with visual resemblance to natural prey items such as zooplankton and fish larvae, thereby increasing the likelihood of ingestion [79]. The color pattern observed likely reflects both environmental availability and selective ingestion behavior.

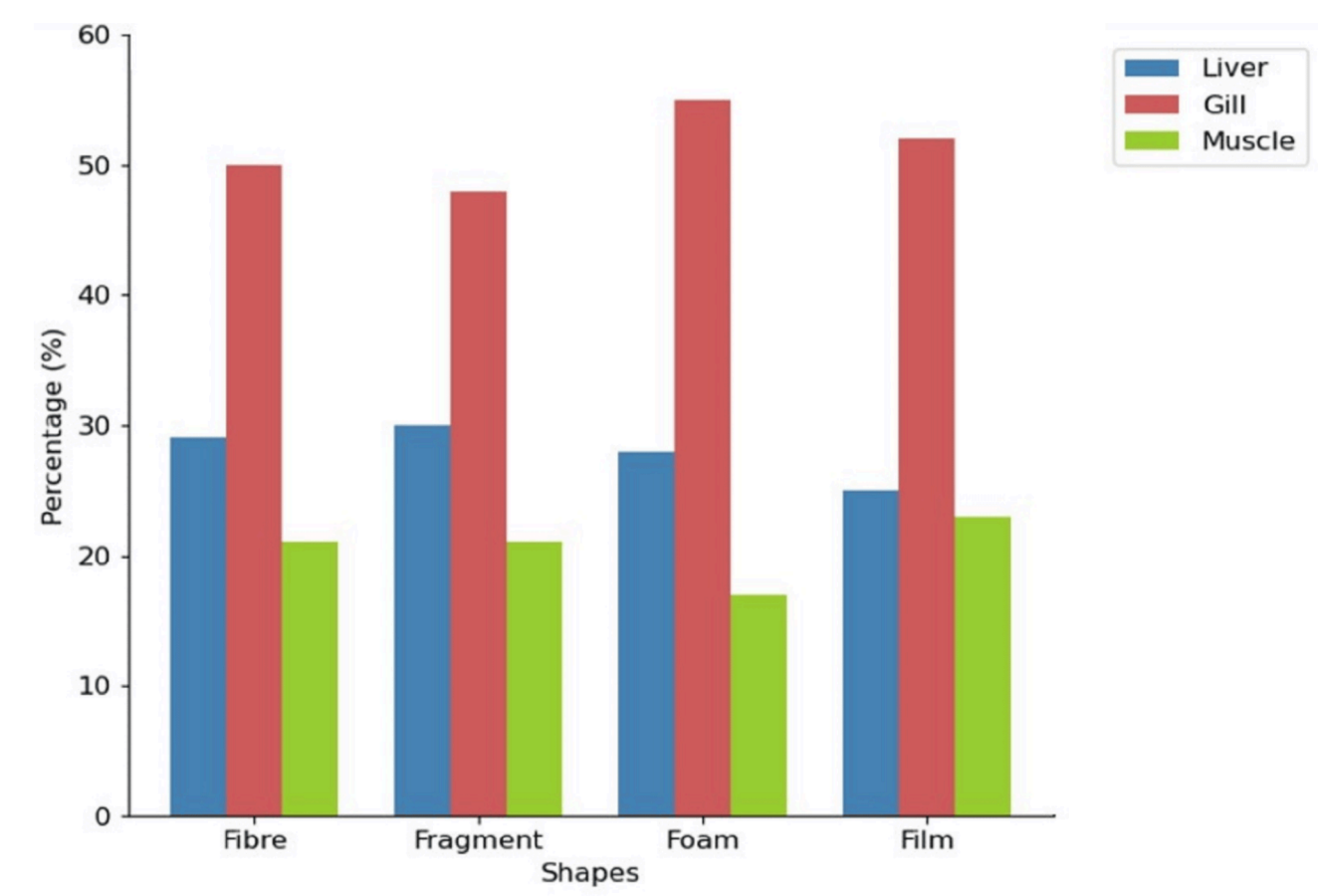


FIGURE 8: Percentage distribution of microplastic shapes in *C. gariepinus* at Eleyele reservoir.

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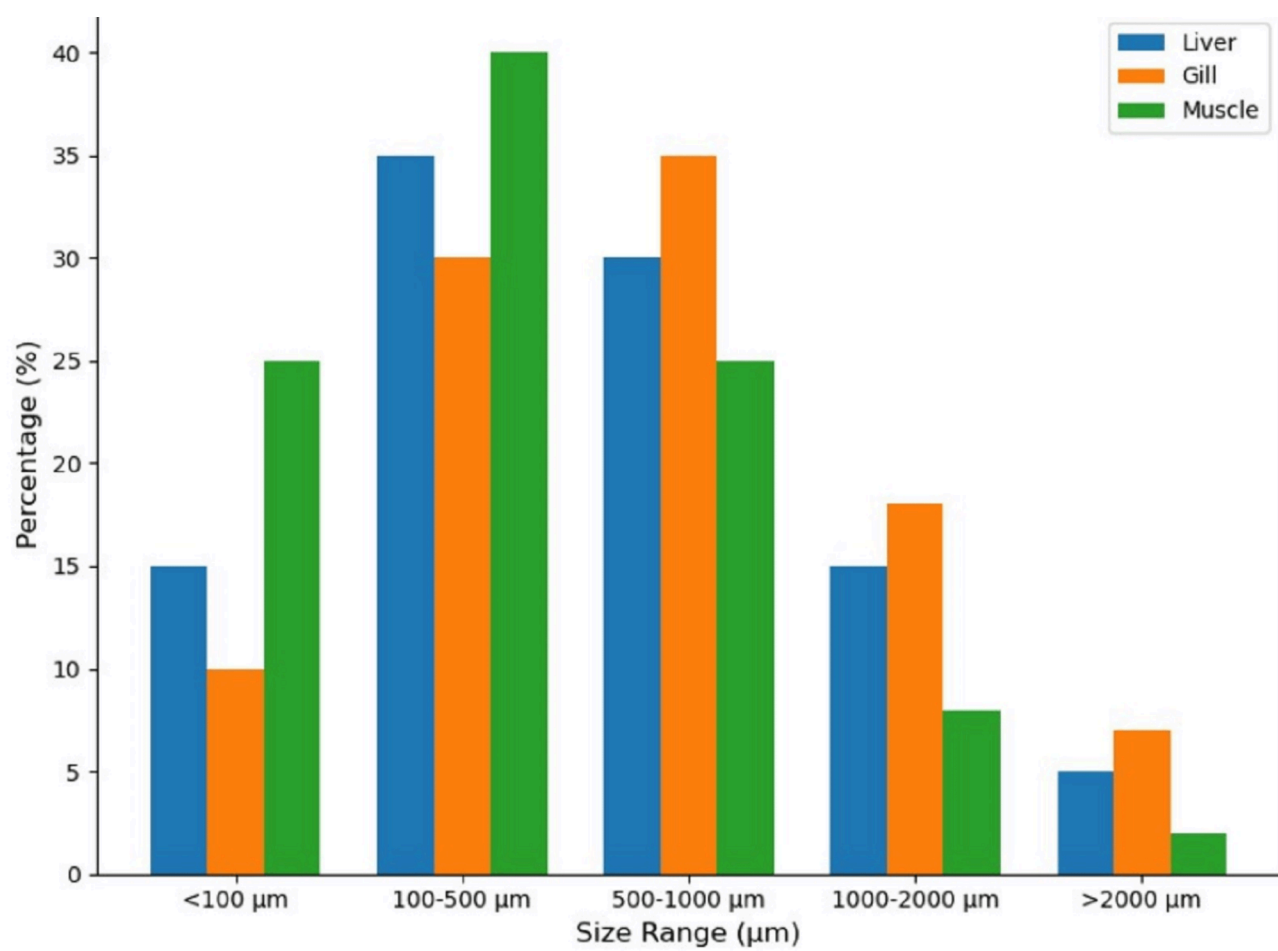


FIGURE 9: Size distribution of MP size in *C. gariepinus* at Eleyele reservoir.

MP, Microplastic

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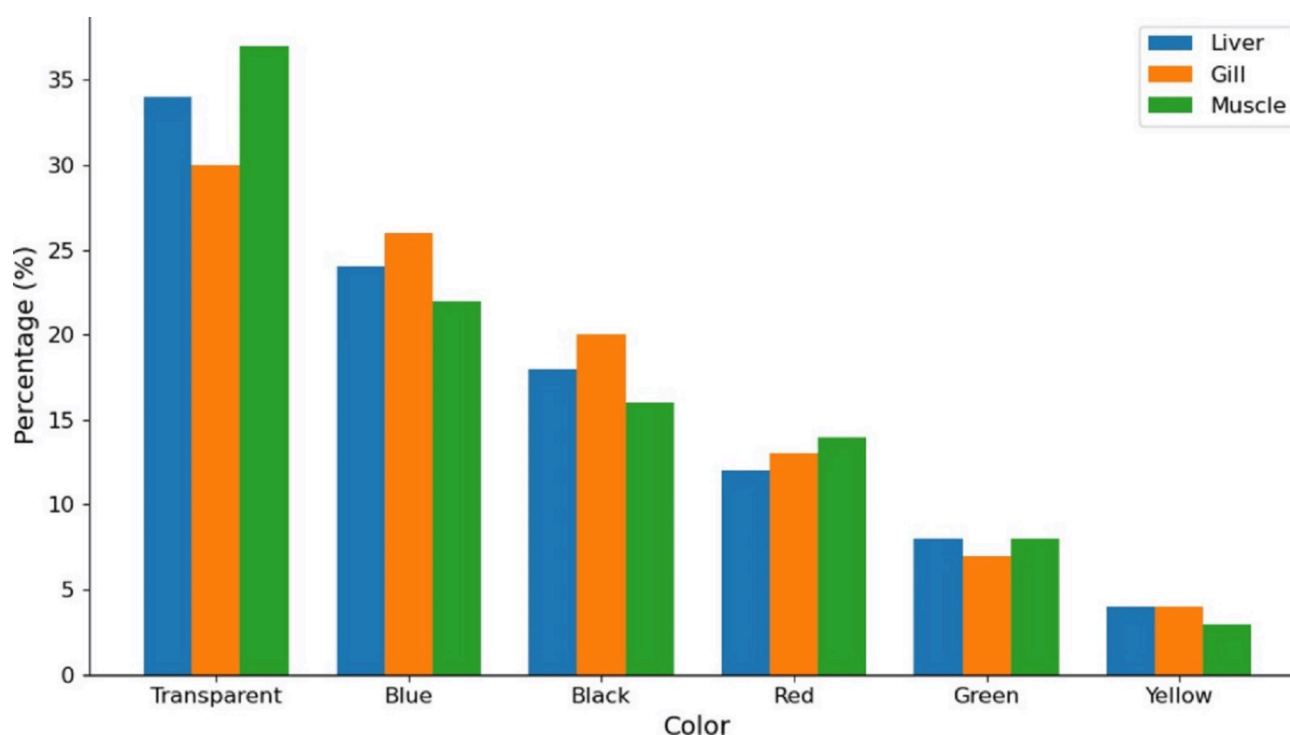


FIGURE 10: Color distribution of MP color in *C. gariepinus* at Eleyele reservoir.

MP, Microplastic

The PHI results presented in Table 2 revealed variations in polymer-associated risk levels among tissues. In muscle tissue, PA recorded the highest PHI value (11.87), corresponding to Hazard Category III (High risk), while PS (4.48) and PE (1.89) were classified as Category II (Medium risk). PP (0.19) and PET (0.93) fell within Category I (Minor risk). Similar trends were observed in liver and gill tissues, where PA consistently recorded the highest PHI values. The elevated PHI associated with PA may be linked to its high abundance across tissues and its potential to adsorb environmental contaminants. Although the PHI values of PP and PET remained relatively low, the consistent occurrence of these polymers in edible tissues remains ecologically and toxicologically relevant. Comparable studies have similarly reported moderate-to-high hazard categories associated with PA and PS polymers [80].

The occurrence of microplastics in *C. gariepinus* raises concerns regarding potential human exposure through fish consumption. Microplastics are known to adsorb and transport persistent organic pollutants, heavy metals, and plastic additives within aquatic environments [26-28]. Once ingested, these contaminants may desorb within biological tissues and contribute to oxidative stress, endocrine disruption, and inflammatory responses [30]. The detection of microplastics in edible muscle tissues therefore represents a potential food safety concern, although the long-term implications for human health remain under investigation [81].

The ecological implications of the observed microplastic contamination are substantial and extend beyond individual fish health. Microplastics can obstruct respiratory surfaces, alter feeding behavior, reduce nutrient assimilation, and induce false satiation in aquatic organisms [64,82]. Such effects may reduce growth efficiency and reproductive performance, potentially altering fish population structure over time [83]. Furthermore, because microplastics persist in aquatic environments for extended periods, they may accumulate within food webs and facilitate the biomagnification of associated contaminants across trophic levels. Therefore, the contamination observed in *C. gariepinus* suggests that the Eleyele reservoir ecosystem may be experiencing broader ecological stress associated with increasing plastic pollution.

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Polymers	Monomers	Sn	Pn (muscle)	PHI Muscle	Pn (Liver)	PHI Liver	Pn (Gill)	PHI Gill
PE	Ethylene	11	17.12	1.89	17.66	1.94	18.60	2.05
PP	Propylene	1	19.42	0.19	19.71	0.20	20.04	0.20
PS	Styrene	30	14.93	4.48	14.28	4.58	15.08	4.25
PA	Hexamethylene diamine	47	25.25	11.87	25.94	11.72	24.36	11.45
PET	Ethanediol	4	23.23	0.93	23.41	0.90	21.96	0.88

TABLE 2: Microplastic polymers hazard index in muscle, liver, and gill.

PHI, Polymer Hazard Ratio; PP, Polypropylene; PE, Polyethylene; PS, Polystyrene; PA, Polyamide; PET, Polyethylene Terephthalate

Heavy metal concentrations in the gill, liver, and muscle tissues of *C. gariepinus* are presented in Table 3. Cadmium remained below detectable limits in all tissues, which is consistent with the FAO/WHO permissible limit of 0.05 mg/kg [84]. In contrast, lead was detected in all tissues, with the highest concentration occurring in the muscle (0.60 ± 0.13 mg/kg), exceeding the FAO/WHO permissible limit of 0.5 mg/kg [84]. The elevated lead concentration in edible muscle tissues poses a potential public health concern because muscle represents the primary portion consumed by humans. Similar studies have reported elevated lead concentrations in fish tissues from contaminated aquatic environments [85].

Chromium concentrations showed a tissue-specific gradient, increasing from gill (0.39 ± 0.04 mg/kg) to liver (1.17 ± 0.05 mg/kg) and muscle (2.64 ± 0.70 mg/kg). Both liver and muscle concentrations exceeded the FAO/WHO recommended range of 0.15-1 mg/kg [84]. Nickel concentrations were particularly elevated across all tissues, with the highest concentration recorded in muscle (10.34 ± 2.86 mg/kg), followed by liver (8.16 ± 2.26 mg/kg) and gill (6.83 ± 1.91 mg/kg). All recorded Nickel concentrations exceeded the permissible limit of 0.5 mg/kg, suggesting significant environmental contamination within the reservoir. Similar elevated nickel concentrations in economically important freshwater fish from three rivers of Malakand Division, Pakistan [86]. The elevated concentrations of Pb, Cr, and Ni observed in the present study indicate persistent anthropogenic inputs into the reservoir, potentially originating from urban runoff, agricultural activities, waste disposal practices, and other human activities within the watershed. The accumulation of these metals in edible tissues also increases the likelihood of dietary exposure among consumers, particularly in communities where fish constitutes a major component of daily protein intake.

Zinc was the most abundant metal detected in this study. Unlike other metals, the liver recorded the highest Zinc concentration (37.90 ± 6.19 mg/kg), followed by gill (29.34 ± 2.38 mg/kg) and muscle (23.57 ± 4.60 mg/kg). The elevated Zinc concentration in the liver is consistent with the liver's role in detoxification and metal-binding protein synthesis. However, all Zn concentrations remained within the FAO/WHO permissible limit of 40 mg/kg [84]. Similar liver-dominant Zinc accumulation patterns have been reported in *Pseudotolithus sp* from the Gulf of Guinea, Ondo State Nigeria fish species [6].

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	Gill	Liver	Muscle	FAO/WHO [84]
Cd	BDL	BDL	BDL	0.05
Pb	0.42 ± 0.08 ^b	0.02 ± 0.04 ^a	0.60 ± 0.13 ^b	0.5
Cr	0.39 ± 0.04 ^a	1.17 ± 0.05 ^b	2.64 ± 0.70 ^c	0.15-1
Ni	6.83 ± 1.91 ^a	8.16 ± 2.26 ^b	10.34 ± 2.86 ^b	0.5
Zn	29.34 ± 2.38 ^b	37.90 ± 6.19 ^c	23.57 ± 4.60 ^a	40

TABLE 3: Heavy metal concentration in *C. gariepinus* from Eleyele reservoir.

Means with the same alphabet are not significantly different ($P > 0.05$) across the row. FAO/WHO, Food and Agriculture Organization/World Health Organization; BDL, Below Detectable Limit; Cd, Cadmium; Pb, Lead; Cr, Chromium; Ni, Nickel; Zn, Zinc

The EDI and HQ for heavy metals in the muscles, gills, and liver of *C. gariepinus* are summarized in Tables 4, 5, and 6. In the muscle tissue, the EDI and HQ values for all metals remained below the threshold of 1 for both children and adults, suggesting that consumption of the muscle will not have an immediate effect on human health. Chromium and Nickel showed the highest HQ values in muscle in both adults and children. In the gills, the HQ values for Nickel exceeded 1 for both population groups. Similarly, the liver showed HQ values above the safe limit for Chromium and Nickel. Zinc did not show a potential risk in the muscle, gill, and liver for children and adults.

The carcinogenic risk and total carcinogenic risk assessments for Pb and Cr are presented in Table 7. Carcinogenic risk values greater than 1×10^{-4} are considered unacceptable [60]. The present result showed that both Pb and Cr could pose significant carcinogenic risks through long-term consumption of *C. gariepinus*. The TCR values, which represent the combined risk from all assessed metals, and their values exceed the acceptable risk threshold of 1×10^{-4} , indicating a potential cumulative carcinogenic risk associated with the consumption of the fish muscle, gill, and liver.

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Metal	Children		Adults	
	EDI	HQ	EDI	HQ
Pb	3.60×10^{-3}	9.00×10^{-1}	3.00×10^{-3}	7.50×10^{-1}
Cr	1.58×10^{-2}	5.28	1.32×10^{-2}	4.4
Ni	6.20×10^{-2}	3.10	5.17×10^{-2}	2.58
Zn	1.41×10^{-1}	4.71×10^{-1}	1.18×10^{-1}	3.93×10^{-1}

TABLE 4: Estimated daily dietary intake and Health quotient of heavy metals in muscles.

EDI, Estimated Daily Dairy Intake; HQ, Hazard Quotient

Metal	Children		Adults	
	EDI	HQ	EDI	HQ
Pb	2.52×10^{-3}	6.30×10^{-1}	2.10×10^{-3}	5.25×10^{-1}
Cr	2.34×10^{-3}	7.80×10^{-1}	1.95×10^{-3}	6.50×10^{-1}
Ni	4.10×10^{-2}	2.05	3.42×10^{-2}	1.71
Zn	1.76×10^{-1}	5.87×10^{-1}	1.47×10^{-1}	4.89×10^{-1}

TABLE 5: Estimated daily dietary intake and health quotient of heavy metals in the gill.

EDI, Estimated Daily Dairy Intake; HQ, Hazard Quotient

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Metal	Children		Adults	
	EDI	HQ	EDI	HQ
Pb	1.20×10^{-4}	3.00×10^{-2}	1.00×10^{-4}	2.50×10^{-2}
Cr	7.02×10^{-3}	2.34	5.85×10^{-3}	1.95
Ni	4.89×10^{-2}	2.45	4.08×10^{-2}	2.04
Zn	2.27×10^{-1}	7.58×10^{-1}	1.90×10^{-1}	6.32×10^{-1}

TABLE 6: Estimated daily dietary intake and health quotient of heavy metals in the liver.

EDI, Estimated Daily Dairy Intake; HQ, Hazard Quotient; Pb, Lead; Cr, Chromium; Ni, Nickel; Zn, Zinc

	Muscle		Gill		Liver	
Metal	Children	Adults	Children	Adults	Children	Adults
Pb	1.26×10^{-3}	1.05×10^{-3}	8.82×10^{-4}	7.35×10^{-4}	4.20×10^{-5}	3.50×10^{-5}
Cr	5.54×10^{-3}	4.62×10^{-3}	1.17×10^{-3}	6.83×10^{-4}	2.46×10^{-3}	2.05×10^{-3}
TCR	2.17×10^{-2}	1.81×10^{-2}	2.05×10^{-3}	1.42×10^{-3}	2.50×10^{-3}	2.08×10^{-3}

TABLE 7: Carcinogenic risk and total carcinogenic risk of heavy metals *C. gariepinus*.

TCR, Total Carcinogenic Risk; Pb, Lead; Cr, Chromium

Heatmap analysis (Figure 17) revealed a relationship between heavy metals and microplastic polymers, with important implications for contaminant behavior in aquatic environments. Zinc showed moderate positive correlations (0.34-0.48) with all polymers, particularly PP and PET. Conversely, lead and chromium exhibited consistent negative associations, with chromium showing the strongest negative correlations (−0.45 to −0.59). Nickel had weak negative associations (−0.12 to −0.22) despite elevated concentrations in fish tissues.

The co-occurrence of microplastics and heavy metals in *C. gariepinus* is ecologically significant because microplastics may serve as carriers of inorganic contaminants within aquatic ecosystems [87]. Plastic particles possess large surface-area-to-volume ratios and can adsorb dissolved metals from the surrounding water through electrostatic interactions, surface complexation, and physical sorption processes [88]. Ingestion or uptake of microplastics by fish may create an additional exposure pathway for heavy metals beyond direct uptake from water, sediment, or food [89-90]. Once ingested, changes in pH, ionic strength, digestive enzymes, and gut surfactants may promote the desorption of adsorbed

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metals from microplastic surfaces, potentially increasing metal bioavailability to aquatic organisms [91]. Consequently, microplastics may influence the distribution, transport, and biological uptake of metals within aquatic food webs, thereby altering contaminant exposure dynamics and ecological risk.

The occurrence of microplastics and heavy metals observed in the present study raises concerns regarding potential combined or synergistic effects on fish health. Such interactions may increase oxidative stress, tissue damage, metabolic disruption, and other sublethal effects compared with exposure to either contaminant alone. However, although both microplastics and heavy metals were detected in *C. gariepinus*, the present study was not designed to determine whether the observed metal burdens were directly associated with microplastic ingestion or whether microplastics acted as vectors for metal transfer. Therefore, causal relationships between microplastic contamination and heavy metal accumulation cannot be established from the current data. Further investigations involving metal analyses of isolated microplastic particles, controlled laboratory exposures, and mechanistic studies are required to determine the extent to which microplastics contribute to heavy metal bioaccumulation in this species.

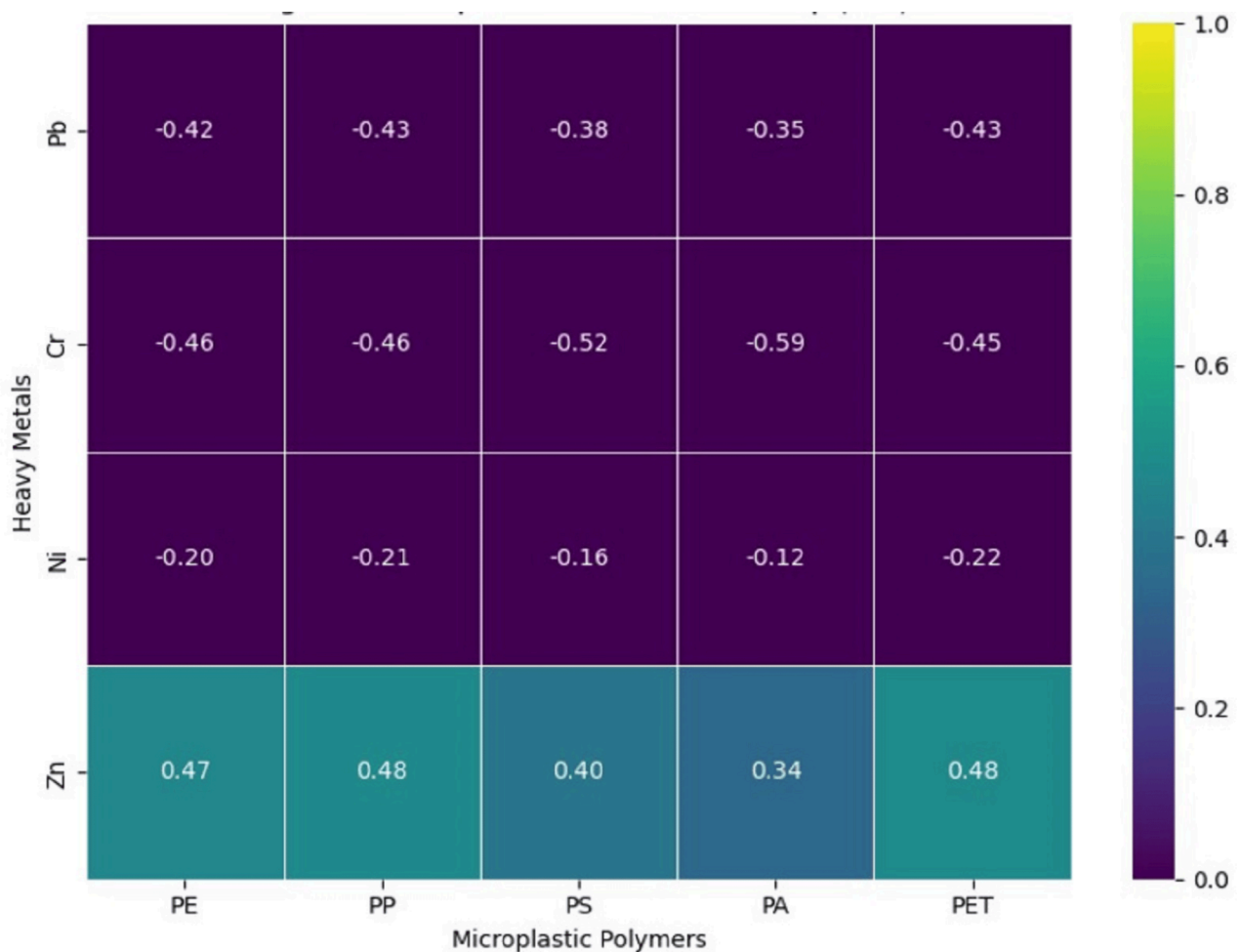


FIGURE 11: Heatmap showing the relationship between heavy metal and microplastic polymer.

PP, Polypropylene; PE, Polyethylene; PS, Polystyrene; PA, Polyamide; PET, Polyethylene Terephthalate

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Conclusions

This study confirms that *C. gariepinus* from Eleyele reservoir is exposed to multiple polymer types (PA, PET, PE, PP, and PS), with PA dominating all tissues and posing a high polymer HR (Category III). Microplastic distribution varied by tissue, shape, size, and color, with gills showing the highest particle loads. Heavy metal analysis revealed concerning levels: Pb in muscle exceeded FAO/WHO limits, while Cr and Ni surpassed safety thresholds across multiple tissues. Although estimated daily intake and hazard quotients for muscle consumption were below concern for immediate health effects, Nickel in gills and chromium/nickel in liver exceeded safe HQ values. CR assessments for Pb and Cr, as well as TCR, exceeded the acceptable threshold (1×10^{-4}), indicating a potential long-term cancer risk from consuming this fish. Overall, the findings highlight significant ecological and human health risks, needing urgent regulatory and mitigation measures.

A limitation of the present study is that sampling was restricted to the rainy season (June-September) and therefore does not capture potential seasonal variations in microplastic abundance and heavy metal accumulation. Seasonal differences in rainfall, runoff, hydrology, and contaminant inputs may influence the distribution and bioavailability of these pollutants in aquatic ecosystems. Consequently, the findings should be interpreted as representative of conditions during the peak rainy season. Future studies incorporating both wet and dry seasons are recommended to provide a more comprehensive assessment of temporal trends in contaminant exposure and associated risks in Eleyele Reservoir.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Oluwafemi Olowojuni, Flora E. Olaifa, Deborah B. Ajayi, Grace B. Ogundeyi

Acquisition, analysis, or interpretation of data: Oluwafemi Olowojuni, Flora E. Olaifa, Deborah B. Ajayi, Grace B. Ogundeyi

Drafting of the manuscript: Oluwafemi Olowojuni, Flora E. Olaifa, Deborah B. Ajayi, Grace B. Ogundeyi

Critical review of the manuscript for important intellectual content: Oluwafemi Olowojuni, Flora E. Olaifa, Deborah B. Ajayi, Grace B. Ogundeyi

Supervision: Oluwafemi Olowojuni, Flora E. Olaifa, Grace B. Ogundeyi

Disclosures

Plant subjects: All authors have confirmed that this study did not involve any herbarium specimen. **Human subjects:** All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** The study involves the use of animal subjects, All procedures involving fish samples in this study were conducted in accordance with the National Institutes of Health guidelines for the care and use of laboratory animals. Fish samples were obtained from local fishermen operating on Eleyele reservoir using gillnets and cast nets, thereby avoiding unnecessary experimental capture solely for research purposes. Samples were handled humanely and transported under appropriate conditions using ice packs to maintain sample integrity. Tissue dissection and preservation procedures were carried out carefully to minimize contamination and ensure compliance with accepted ethical standards for animal research. No live experimental manipulation was performed on the fish before tissue collection. ethics committee, protocol no Not Applicable. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the

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previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

References

1. Mustafa SA, Al-Rudainy AJ, Salman NM: [Effect of environmental pollutants on fish health: an overview](#). Egyptian Journal of Aquatic Research. 2024, 50:225-233. [10.1016/j.ejar.2024.02.006](#)
2. Shetty SS, Deepthi D, Harshitha S, et al.: [Environmental pollutants and their effects on human health](#). Heliyon. 2023, 9:1-13. [10.1016/j.heliyon.2023.e19496](#)
3. Briffa J, Sinagra E, Blundell R: [Heavy metal pollution in the environment and their toxicological effects on humans](#). Heliyon. 2020, 6:1-26. [10.1016/j.heliyon.2020.e04691](#)
4. Páez-Osuna F, Espinoza AC, Figueroa ET, Saucedo BCJ, Bergés-Tiznado ME: [Tilapia as a model fish for biomonitoring of metal pollution in dams associated with mining watersheds: contrasting diagnosis from different tissues and health risk assessment](#). Environmental Geochemistry and Health. 2024, 46:1-18. [10.1007/s10653-024-02232-8](#)
5. Olowojuni OA, Amulejoye FD, Ikuesan BB, Maulu S, Bwalya H, Hasimuna OJ: [Water quality, heavy metal contamination, and ecological risk assessment in Asejire reservoir, Nigeria](#). Journal of Freshwater Ecology. 2025, 40:1-23. [10.1080/02705060.2025.2516505](#)
6. Olowojuni O, Olaifa FE, Oyebola OO, Ayotunde DT, Kelani AZ, Olusola SE: [Seasonal and spatial variations in water quality, heavy metal concentration in water, sediment and bioaccumulation in Pseudotolithus species from the Gulf of Guinea, Ondo state, Nigeria](#). Environmental Sciences Europe. 2025, 37:1-25. [10.1186/s12302-025-01221-7](#)
7. Oziegbe O, Oziegbe EJ, Ojo-Omoniyi O: [Bioremediation of heavy metals in aquatic environment: a review](#). Cleaner Chemical Engineering. 2025, 11:1-18. [10.1016/j.clce.2025.100193](#)
8. Afzal A, Mahreen N: [Emerging insights into the impacts of heavy metals exposure on health, reproductive and productive performance of livestock](#). Frontiers in Pharmacology. 2024, 15:1-18. [10.3389/fphar.2024.1375137](#)
9. Cheng YF, Zhao YJ, Chen C, Zhang F: [Heavy metals toxicity: mechanism, health effects, and therapeutic interventions](#). MedComm. 2025, 6:1-25. [10.1002/mco2.70241](#)
10. Xu H, Newton R, Love DC, Zhao Y, Toppe J, Zhang W: [Heavy metal risks in aquatic foods](#). Environment International. 2025, 205:1-21. [10.1016/j.envint.2025.109831](#)
11. Blanchfield PJ, Rudd JWM, Hrenchuk LE, et al.: [Experimental evidence for recovery of mercury-contaminated fish populations](#). Nature. 2021, 601:74-78. [10.1038/s41586-021-04222-7](#)
12. Andrady AL: [The plastic in microplastics: a review](#). Marine Pollution Bulletin. 2017, 119:12-22. [10.1016/j.marpolbul.2017.01.082](#)
13. Jambeck JR, Geyer R, Wilcox C, et al.: [Plastic waste inputs from land into the ocean](#). Science. 2015, 347:768-771. [10.1126/science.1260352](#)
14. Geyer R, Jambeck Jenna R, Law KL: [Production, use, and fate of all plastics ever made](#). Science Advances. 2017, 3:1-5. [10.1126/sciadv.1700782](#)
15. Sarijan S, Azman S, Said MIM, Jamal MH: [Microplastics in freshwater ecosystems: a recent review of occurrence, analysis, potential impacts, and research needs](#). Environmental Science and Pollution Research International. 2020, 28:1341-1356. [10.1007/s11356-020-11171-7](#)
16. Ziani K, Ioniță-Mîndrican CB, Mititelu M, et al.: [Microplastics: a real global threat for environment and food safety: a state of the art review](#). Nutrients. 2023, 15:1-34. [10.3390/nu15030617](#)
17. Andrady AL: [Microplastics in the marine environment](#). Marine Pollution Bulletin. 2011, 62:1596-1605. [10.1016/j.marpolbul.2011.05.030](#)

How to cite this article:

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18. Lebreton LCM, van der Zwet J, Damsteeg JW, Boyan S, Andrady A, Reisser J: [River plastic emissions to the world's oceans](#). Nature Communications. 2017, 8:1-10. [10.1038/ncomms15611](#)
19. de Castro DG, da Silva AL, Lopes MDN, Freire AS, Leite NK : [Effect of urbanization and water quality on microplastic distribution in Conceição Lagoon watershed, Brazil](#). Environmental Science and Pollution Research. 2024, 31:28870-28889.
20. Galafassi S, Campanale C, Massarelli C, Uricchio VF, Volta P: [Do freshwater fish eat microplastics? A review with a focus on effects on fish health and predictive traits of MPs ingestion](#). Water. 2021, 13:1-20. [10.3390/w13162214](#)
21. Akter MS, Kumar CT, Ghosh GC, Nice MS, Zaman S, Khan AS: [Microplastics and heavy metals in freshwater fish species in the southwestern region of Bangladesh: an emerging concern for public health](#). Emerging Contaminants. 2024, 10:1-13. [10.1016/j.emcon.2024.100325](#)
22. Walker TR, Wang L, Horton A, Xu EG: [Micro\(nano\)plastic toxicity and health effects: special issue guest editorial](#). Environment International. 2022, 170:1-4. [10.1016/j.envint.2022.107626](#)
23. Karbalaeei S, Hanachi P, Rafiee G, Seifori P, Walker TR: [Toxicity of polystyrene microplastics on juvenile *Oncorhynchus mykiss* \(rainbow trout\) after individual and combined exposure with chlorpyrifos](#). Journal of Hazardous Materials. 2020, 403:123980. [10.1016/j.jhazmat.2020.123980](#)
24. Cole M, Lindeque P, Fileman E, Halsband C, Galloway TS: [The impact of polystyrene microplastics on feeding, function and fecundity in the marine copepod *Calanus helgolandicus*](#). Environmental Science and Technology. 2015, 49:1130-1137. [10.1021/es504525u](#)
25. Bakir A, Rowland SJ, Thompson RC: [Enhanced desorption of persistent organic pollutants from microplastics under simulated physiological conditions](#). Environmental Pollution. 2014, 185:16-23. [10.1016/j.envpol.2013.10.007](#)
26. Fisner M, Taniguchi S, Moreira F, Bicego MC, Turra A: [Polycyclic aromatic hydrocarbons \(PAHs\) in plastic pellets: variability in the concentration and composition at different sediment depths in a sandy beach](#). Marine Pollution Bulletin. 2013, 70:219-226. [10.1016/j.marpolbul.2013.03.008](#)
27. Rochman CM, Browne MA, Halpern BS, et al.: [Classify plastic waste as hazardous](#). Nature. 2013, 494:169-171. [10.1038/494169a](#)
28. Krüger O, Kalbe U, Meißner K, Sobottka S: [Sorption effects interfering with the analysis of polycyclic aromatic hydrocarbons \(PAH\) in aqueous samples](#). Talanta. 2014, 122:151-156. [10.1016/j.talanta.2014.01.038](#)
29. Hamed M, Osman AGM, Badrey AEA, Soliman HAM, Sayed AEDH: [Microplastics-induced eryptosis and poikilocytosis in early-juvenile Nile tilapia \(*Oreochromis niloticus*\)](#). Frontiers in Physiology. 2021, 12:1-10. [10.3389/fphys.2021.742922](#)
30. Jadhav EB, Sankhla MS, Bhat RA, Bhagat DS: [Microplastics from food packaging: an overview of human consumption, health threats, and alternative solutions](#). Environmental Nanotechnology, Monitoring & Management. 2021, 16:100608. [10.1016/j.enmm.2021.100608](#)
31. Liu S, Shi J, Wang J, et al.: [Interactions between microplastics and heavy metals in aquatic environments: a review](#). Frontiers in Microbiology. 2021, 12:1-14. [10.3389/fmicb.2021.652520](#)
32. Khalid N, Aqeel M, Noman A, Khan SM, Akhter N: [Interactions and effects of microplastics with heavy metals in aquatic and terrestrial environments](#). Environmental Pollution. 2021, 290:118104. [10.1016/j.envpol.2021.118104](#)
33. Rasool A, Halfar J, Brožová K, et al.: [Interactions of microplastics with heavy metals in the aquatic environment: mechanisms and mitigation](#). Journal of Hazardous Materials Advances. 2026, 21:1-24. [10.1016/j.hazadv.2025.100984](#)
34. Bhuyan MS: [Effects of microplastics on fish and in human health](#). Frontiers in Environmental Science. 2022, 10:1-17. [10.3389/fenvs.2022.827289](#)
35. Leslie HA, van Velzen MJM, Brandsma SH, Vethaak AD, Garcia-Vallejo JJ, Lamoree MH: [Discovery and quantification of plastic particle pollution in human blood](#). Environment International. 2022, 163:1-8. [10.1016/j.envint.2022.107199](#)
36. Rahman A, Sarkar A, Yadav OP, Achari G, Slobodnik J: [Potential human health risks due to environmental exposure to nano- and microplastics and knowledge gaps: a scoping review](#). The Science of the Total Environment. 2020, 757:143872. [10.1016/j.scitotenv.2020.143872](#)
37. Alam M, Rohani MF, Hossain MS: [Heavy metals accumulation in some important fish species cultured in commercial fish farm of Natore, Bangladesh and possible health risk evaluation](#). Emerging Contaminants. 2023, 9:1-8. [10.1016/j.emcon.2023.100254](#)
38. Stetkiewicz S, Norman RA, Allison EH, et al.: [Seafood in food security: a call for bridging the terrestrial-aquatic divide](#). Frontiers in Sustainable Food Systems. 2022, 5:1-8. [10.3389/fsufs.2021.703152](#)

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39. Oros A: [Bioaccumulation and trophic transfer of heavy metals in marine fish: ecological and ecosystem-level impacts](#). Journal of Xenobiotics. 2025, 15:1-38. [10.3390/jox15020059](#)
40. Hearst S, Selby T, Kazery J, et al.: [Fish as environmental sentinels for metal contaminants of human health concern in the lower Mississippi river basin](#). Journal of Trace Elements in Medicine and Biology. 2025, 87:1-10. [10.1016/j.jtemb.2025.127593](#)
41. Horalskyi LP, Tsanko IV, Gutty BV, Loboiko YV, Rud OG, Shevchenko LV: [Features of the morphology of the respiratory organs of *Clarias gariepinus* \(Burchell, 1822\) of the catfish family](#). Ukrainian Journal of Veterinary and Agricultural Sciences. 2025, 8:84-90. [10.32718/ujvas8-3.11](#)
42. Mbanga B, van Dyk C, Maina JN: [Morphometric and morphological study of the respiratory organs of the bimodally-breathing African sharp-tooth catfish \(*Clarias gariepinus*\): Burchell \(1822\)](#). Zoology. 2018, 130:6-18. [10.1016/j.zool.2018.07.005](#)
43. Modu AB, Onyia LU, Mohammed AM, Gadaka YM: [Comparative reproductive performance of strains of *Clarias gariepinus* from two different hydrological zones of Nigeria](#). Bayero Journal of Pure and Applied Sciences. 2022, 15:9-14.
44. Kareem OK, Ajani EK, Orisasona O, Olanrewaju AN: [The sex ratio, gonadosomatic index, diet composition and fecundity of African Pike, *Hepsetus odoe* \(Bloch, 1794\) in Eleyele Lake, Nigeria](#). Journal of Fisheries & Livestock Production. 2015, 3:1-4.
45. Adeogun AO, Ibor OR, Khan EA, Chukwuka AV, Omogbemi ED, Arukwe A: [Detection and occurrence of microplastics in the stomach of commercial fish species from a municipal water supply lake in southwestern Nigeria](#). Environmental Science and Pollution Research. 2020, 27:31035-31045. [10.1007/s11356-020-09031-5](#)
46. Akter S, Fardous Z, Aktar J, Rahman MA, Chowdhury MAZ, Sarkar S, Billah MB: [Environmental contamination of heavy metals in some dried fish of coastal regions of Bangladesh](#). Bangladesh Journal of Zoology. 2019, 47:293-304. [10.3329/bjz.v47i2.44340](#)
47. Chakraborty TK, Chandra GG, Hossain MR, et al.: [Human health risk and receptor model-oriented sources of heavy metal pollution in commonly consumed vegetable and fish species of high Ganges river floodplain agro-ecological area, Bangladesh](#). Heliyon. 2022, 8:1-15. [10.1016/j.heliyon.2022.e11172](#)
48. Rahman MS, Molla AH, Saha N, Rahman A: [Study on heavy metals levels and its risk assessment in some edible fishes from Bangshi River, Savar, Dhaka, Bangladesh](#). Food Chemistry. 2012, 134:1847-1854. [10.1016/j.foodchem.2012.03.099](#)
49. Masura J, Baker J, Foster G, Arthur C: [Laboratory methods for the analysis of microplastics in the marine environment: Recommendations for quantifying synthetic particles in waters and sediments](#) (NOAA Technical Memorandum. Herring C (ed): NOAA Marine Debris Division, Silver Springs, MD; 2015. [10.25607/OBP-604](#)
50. McNeish RE, Kim LH, Barrett HA, Mason SA, Kelly JJ, Hoellein TJ: [Microplastic in riverine fish is connected to species traits](#). Scientific Reports. 2018, 8:1-12. [10.1038/s41598-018-29980-9](#)
51. Hidalgo-Ruz V, Gutow L, Thompson R C, Thiel M: [Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification](#). Environmental Science & Technology. 2012, March, 46(6):3060-3075. [10.1021/es2031505](#)
52. Lithner D, Larsson Å, Dave G: [Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition](#). Science of the Total Environment. 2011, 409:3309-3324. [10.1016/j.scitotenv.2011.04.038](#)
53. Ranjani M, Veerasingam S, Venkatachalapathy R, Mugilarasan M, Bagaev A, Mukhanov V, Vethamony P: [Assessment of potential ecological risk of microplastics in the coastal sediments of India: a meta-analysis](#). Marine Pollution Bulletin. 2021, 163:1-12. [10.1016/j.marpolbul.2021.111969](#)
54. Huang L, Li QP, Li H, et al.: [Microplastic contamination in coral reef fishes and its potential risks in the remote Xisha areas of the South China Sea](#). Marine Pollution Bulletin. 2022, 186:114399. [10.1016/j.marpolbul.2022.114399](#)
55. Matouke MM, Abdullahi KL: [Assessment of heavy metals contamination and human health risk in *Clarias gariepinus* \[Burchell, 1822\] collected from Jabi Lake, Abuja, Nigeria](#). Scientific African. 2020, 7:1-7. [10.1016/j.sciaf.2020.e00292](#)
56. Manuel MS, Claudia C, Vanessa H: [Shellfish from Todos OS Santa Bay, Bahia, Brazil, treat or threat?](#). Marine Pollution Bulletin. 2011, 62:2254-2264.
57. Qin LY, Zhang RC, Liang YD, et al.: [Concentrations and health risks of heavy metals in five major marketed marine bivalves from three coastal cities in Guangxi, China](#). Ecotoxicology and Environmental Safety. 2021, 223:1-13. [10.1016/j.ecoenv.2021.112562](#)
58. Saha N, Mollah MZI, Alam MF, Safiur RM: [Seasonal investigation of heavy metals in marine fishes captured from the Bay of Bengal and the implications for human health risk assessment](#). Food Control. 2016, 70:110-118. [10.1016/j.foodcont.2016.05.040](#)
59. Alsafran M, Usman K, Rizwan M, Ahmed T, Al Jabri H: [The carcinogenic and non-carcinogenic health risks of metal\(oid\)s bioaccumulation in leafy vegetables: a consumption advisory](#). Frontiers in Environmental Science. 2021, 9:1-11.

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[10.3389/fenvs.2021.742269](https://doi.org/10.3389/fenvs.2021.742269)

60. Fryer M, Collins CD, Ferrier H, Colville RN, Nieuwenhuijsen MJ: [Human exposure modelling for chemical risk assessment: a review of current approaches and research and policy implications](#). Environmental Science & Policy. 2006, 9:261-274. [10.1016/j.envsci.2005.11.011](https://doi.org/10.1016/j.envsci.2005.11.011)
61. Chen M, Jin M, Tao P, Wang Z, Xie W, Yu X, Wang K: [Assessment of microplastics derived from mariculture in Xiangshan Bay, China](#). Environmental Pollution. 2018, 242:1146-1156. [10.1016/j.envpol.2018.07.133](https://doi.org/10.1016/j.envpol.2018.07.133)
62. Wang J, Wang M, Ru S, Liu X: [High levels of microplastic pollution in the sediments and benthic organisms of the South Yellow Sea, China](#). the science of the total environment. 2018, 651:1661-1669. [10.1016/j.scitotenv.2018.10.007](https://doi.org/10.1016/j.scitotenv.2018.10.007)
63. Cordova MR: [Marine plastic debris: distribution, abundance, and impact on our seafood](#). Handbook of Research on Environmental and Human Health Impacts of Plastic Pollution. Wani KA, Ariana L, Zuber SM (ed): IGI Global Scientific Publishing, NY, USA; 94-121.
64. Jaafar N, Azfaralariff A, Musa SM, Mohamed M, Yusoff AH, Lazim AM: [Occurrence, distribution and characteristics of microplastics in gastrointestinal tract and gills of commercial marine fish from Malaysia](#). Science of the Total Environment. 2021, 799:149457. [10.1016/j.scitotenv.2021.149457](https://doi.org/10.1016/j.scitotenv.2021.149457)
65. Deng Y, Zhang Y, Lemos B, Ren H: [Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure](#). Scientific Reports. 2017, 7:1-10.
66. Jovanović B: [Ingestion of microplastics by fish and its potential consequences from a physical perspective](#). Integrated Environmental Assessment and Management. 2017, 13:510-515. [10.1002/ieam.1913](https://doi.org/10.1002/ieam.1913)
67. Kılıç E, Yücel N: [Microplastic occurrence in the gastrointestinal tract and gill of bioindicator fish species in the northeastern Mediterranean](#). Marine Pollution Bulletin. 2022, 177:113556. [10.1016/j.marpolbul.2022.113556](https://doi.org/10.1016/j.marpolbul.2022.113556)
68. Yin X, Wu J, Liu Y, et al.: [Accumulation of microplastics in fish guts and gills from a large natural lake: selective or non-selective?](#). Environmental Pollution. 2022, 309:119785. [10.1016/j.envpol.2022.119785](https://doi.org/10.1016/j.envpol.2022.119785)
69. Menéndez D, Blanco-Fernandez C, Machado-Schiaffino G, Ardura A, Garcia-Vazquez E: [High microplastics concentration in liver is negatively associated with condition factor in the Benguela hake Merluccius polli](#). Ecotoxicology and Environmental Safety. 2023, 262:1-10. [10.1016/j.ecoenv.2023.115135](https://doi.org/10.1016/j.ecoenv.2023.115135)
70. Roch S, Friedrich C, Brinker A: [Uptake routes of microplastics in fishes: practical and theoretical approaches to test existing theories](#). Scientific Reports. 2020, 10:1-12. [10.1038/s41598-020-60630-1](https://doi.org/10.1038/s41598-020-60630-1)
71. Gao J, Shen T, Wang L, Yang Q, Wang J, Zhang D: [Exposure pathway derived accumulation of microplastics in freshwater fish: a critical review](#). Journal of Hazardous Materials. 2025, 500:140270. [10.1016/j.jhazmat.2025.140270](https://doi.org/10.1016/j.jhazmat.2025.140270)
72. Karami A, Golieskardi A, Ho YB, Larat V, Salamatinia B: [Microplastics in eviscerated flesh and excised organs of dried fish](#). Scientific Reports. 2017, 7:1-9. [10.1038/s41598-017-05828-6](https://doi.org/10.1038/s41598-017-05828-6)
73. Nodehi RN, Hadi M, Hosseinzadeh A, Azizi N: [Comprehensive systematic review and meta-analysis of microplastic prevalence and abundance in freshwater fish species: the effect of fish species habitat, feeding behavior, and Fulton's condition factor](#). Journal of Environmental Health Science and Engineering. 2024, 22:365-380. [10.1007/s40201-024-00907-z](https://doi.org/10.1007/s40201-024-00907-z)
74. Nithin A, Sundaramanickam A, Iswarya P, Babu OG: [Hazard index of microplastics contamination in various fishes collected off Parangipettai, Southeast coast of India](#). Chemosphere. 2022, 307:136037. [10.1016/j.chemosphere.2022.136037](https://doi.org/10.1016/j.chemosphere.2022.136037)
75. Dai Z, Zhang H, Zhou Q, et al.: [Occurrence of microplastics in the water column and sediment in an inland sea affected by intensive anthropogenic activities](#). Environmental Pollution. 2018, 242:1557-1565. [10.1016/j.envpol.2018.07.131](https://doi.org/10.1016/j.envpol.2018.07.131)
76. Sayed AEDH, Hamed M, Badrey AEA, Ismail RF, Osman YAA, Osman AGM, Soliman HAM: [Microplastic distribution, abundance, and composition in the sediments, water, and fishes of the Red and Mediterranean seas, Egypt](#). Marine Pollution Bulletin. 2021, 173:112966. [10.1016/j.marpolbul.2021.112966](https://doi.org/10.1016/j.marpolbul.2021.112966)
77. Doherty VF, Aneyo IA, Fatunsin OT, et al.: [Assessment of fishes, sediment and water from some inland rivers across the six geopolitical zones in Nigeria for microplastics](#). Environmental Analysis Health and Toxicology. 2024, 39:1-14.
78. Zhu J, Zhang Q, Li Y, et al.: [Microplastic pollution in the Maowei Sea, a typical mariculture bay of China](#). Science of the Total Environment. 2018, 658:62-68. [10.1016/j.scitotenv.2018.12.192](https://doi.org/10.1016/j.scitotenv.2018.12.192)
79. Jin Y, Lu L, Tu W, Luo T, Fu Z: [Impacts of polystyrene microplastic on the gut barrier, microbiota and metabolism of mice](#). Science of the Total Environment. 2018, 649:308-317. [10.1016/j.scitotenv.2018.08.353](https://doi.org/10.1016/j.scitotenv.2018.08.353)

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80. Ory NC, Gallardo C, Lenz M, Thiel M: [Capture, swallowing, and egestion of microplastics by a planktivorous juvenile fish](#). Environmental Pollution. 2018, 240:566-573. [10.1016/j.envpol.2018.04.093](#)
81. Van Cauwenberghe L, Janssen CR: [Microplastics in bivalves cultured for human consumption](#). Environmental Pollution. 2014, 193:65-70. [10.1016/j.envpol.2014.06.010](#)
82. Cordova MR, Nurhati IS, Riani E, Nurhasanah, Iswari MY: [Unprecedented plastic-made personal protective equipment \(PPE\) debris in river outlets into Jakarta Bay during COVID-19 pandemic](#). Chemosphere. 2020, 268:129360. [10.1016/j.chemosphere.2020.129360](#)
83. Pozo K, Gomez V, Torres M, et al.: [Presence and characterization of microplastics in fish of commercial importance from the Biobío region in central Chile](#). Marine Pollution Bulletin. 2019, 140:315-319. [10.1016/j.marpolbul.2019.01.025](#)
84. Joint FAO/WHO Expert Committee on Food Additives, Food and Agriculture Organization of the United Nations & World Health Organization. Evaluation of certain food additives and contaminants: thirty-third report of the Joint FAO/WHO Expert Committee on Food Additives. World Health Organization. World Health Organization. (1989). Accessed: July 14, 2026: <https://iris.who.int/handle/10665/39252>.
85. Serviere-Zaragoza E, Lluch-Cota SE, Mazariegos-Villarreal A, Balart EF, Valencia-Valdez H, Méndez-Rodríguez LC: [Cadmium, lead, copper, zinc, and iron concentration patterns in three marine fish species from two different mining sites inside the Gulf of California, Mexico](#). International Journal of Environmental Research and Public Health. 2021, 18:1-18. [10.3390/ijerph18020844](#)
86. Ali H, Khan E: [Bioaccumulation of Cr, Ni, Cd and Pb in the economically important freshwater fish Schizothorax plagiostomus from three rivers of Malakand Division, Pakistan: risk assessment for human health](#). Bulletin of Environmental Contamination and Toxicology. 2018, 102:77-83. [10.1007/s00128-018-2500-8](#)
87. Soliman HAM, Salaah SM, Hamed M, Sayed AEDH: [Toxicity of co-exposure of microplastics and lead in African catfish \(Clarias gariepinus\)](#). Frontiers in Veterinary Science. 2023, 10:1-10. [10.3389/fvets.2023.1279382](#)
88. Rahman AMNAA, Rusli A, Abdullah MK, et al.: [A review of microplastic surface interactions in water and potential capturing methods](#). Water Science and Engineering. 2024, 17:361-370. [10.1016/j.wse.2023.11.008](#)
89. Devi A, De Silva YSK, Tyagi L, Aaryashree: [The individual and combined effects of microplastics and heavy metals on marine organisms](#). Microplastics. 2025, 4:1-20. [10.3390/microplastics4030038](#)
90. Trivedi A, Bakhasha J, Saxena V, et al.: [Microplastic-metal interactions and their toxicological effects in fish: a comprehensive review](#). Journal of Hazardous Materials Advances. 2026, 21:1-18. [10.1016/j.hazadv.2026.101005](#)
91. Binda G, Spanu D, Monticelli D, et al.: [Unfolding the interaction between microplastics and \(trace\) elements in water: a critical review](#). Water Research. 2021, 204:1-16. [10.1016/j.watres.2021.117637](#)

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