Assessing the bioaccumulation of microplastics in commercially important fish species

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Abstract

Microplastics as defined in this study are plastic particles less than 5 mm in diameter. These particles have been highlighted in recent studies as a major concern due to their potency as pollutants. Microplastics endanger ecosystems and marine life, and, subsequently humans, and claim an ever-growing proportion of concern. This study examines bioaccumulation of microplastic contaminants found in commercial-grade fish stocks from coastal and offshore waters. The study incorporates species considered crucial to the fisheries and aquaculture industries on a global scale. It further assesses the extent, concentration, and characteristics of microplastics located within the gastrointestinal tracts and tissues of the target fish. Key maritime zones were sampled. Recovery of microplastics was achieved by density separation and enzymatic digestion, and polymes were identified using Fourier-transform Infrared spectroscopy (FTIR). Interspecies differences were significant in regard to microplastic accumulation and this study attributes this to differences in animals' feeding strategies, depth of their habitats, and their trophic position. Both pelagic and demersal species showed differences in burdening microplastics with filter feeders and omnivorous species having more. These add up to the diet-based differences between trophic levels. Concern for the safety of seafood products and potential risks to human consumers highlight the danger of long-term consequences on fish tissue. These findings highlight the necessity to improve the regulation of marine litter, waste disposal in the vicinity of fishing harbors, and to implement comprehensive surveillance systems from a maritime viewpoint. Additionally, the results illustrate the need for plastic pollution stemming from anthropogenic activities to be managed for the sustainable economic and ecological protection of resources, constraining uncontrolled and detrimental spending on maintaining resources. This analysis provides fundamental information for the planning of marine preservation policies, advancing food safety for public health, and sustaining fragile coastal communities reliant on fisheries services.

Keywords: Bioaccumulation, Microplastics, Fish species, Commercial fisheries, Marine pollution, Seafood safety, Maritime applications

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Introduction

Microplastics are plastic particles less than 5 millimeters in diameter and may come from larger pieces degrading into smaller fragments or created intentionally for products like cosmetics and industrial abrasives (Andrady, 2011). These pollutants are now commonly found in the oceans because of the rampant use and poor disposal of plastics. Zooplankton, bivalves, crustaceans, and fish are a few examples of marine organisms that have access to these particles, and many have shown to be bioavailable and ingestible (Cole *et al.*, 2011; Çağıltay *et al.*, 2023). Their euphemistic characteristics make them prone to being devoured by aquatic organisms, leading to dire consequences for the environment and physical well-being (Abraheem, 2023; Abd, 2023). Bioaccumulation describes the biological concentration of particular substances, including microplastics and persistent organic pollutants that accrue within the organism over time (Prasath, 2024). Ingestive actions or trophic transfer bioaccumulation pathways are more complex than simple environmental contact and generally result in greater concentrations than in the environment itself (Setälä *et al.*, 2014; Mohammad Abbas *et al.*, 2024). Microplastics, which can adsorb and transport various hazardous substances such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and even heavy metals, act as dangerous pollutants conduits into ecosystems (Wright *et al.*, 2013). Subsequent to consumption, these particles may get trapped within the gastrointestinal cavity, gills, and in more advanced cases, even foster migration into muscles of fish, resulting in physical inflammation, oxidative stress, nutrient deficiency, and impedance of nutrient absorption (Rochman *et al.*, 2013).

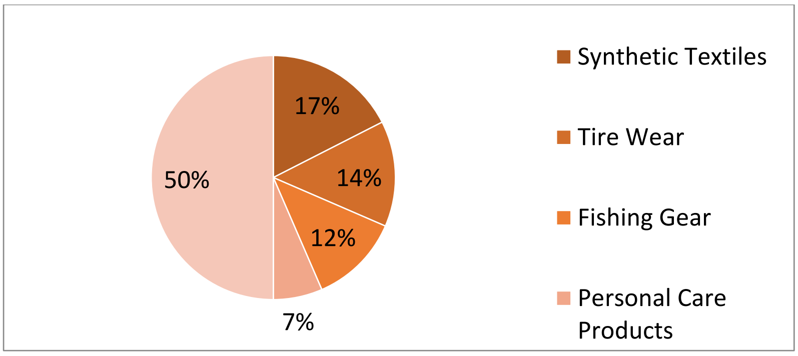

Figure 1: Global sources of microplastic pollution.

Figure 1 outlines the world's most significant sources of microplastic pollution, depicted through a pie chart. The most significant contributor worldwide is synthetic textiles, which is 35% of the total microplastic emissions. These particles are mainly shed during the laundering of synthetic fabrics like polyester and nylon. Comes next is tire wear at 28% from the abraded tires on the highways, which subsequently wash into water bodies via runoff. Fishing gear, especially nets and ropes accounts for 24%, depicting the far-reaching impact of human activities at sea. Lastly, personal care products like exfoliating scrubs and some types of toothpaste account for 13%, though many nations are removing microbeads from these products. It is apparent from this distribution that microplastic pollution stems from both terrestrial and marine activities which indicates the necessity for a cross disciplinary strategy for dealing with the problem. The presence of microplastics in ecologically and commercially important fish species poses serious ecological, economic, and health risks. Fish species like mackerel, sardines, and anchovies along with cod are foundational to the circulatory system of international seafood markets and are central to the diet of millions worldwide (FAO, 2018; Yeo & Jiang, 2024). The presence of microplastics in fish intended for human consumption serves as an alarming indicator of the pathways for pollutants to infiltrate human biology. From her studies, Barboza and Gimenez has shown that 80% of the fish sampled from Portuguese coastal waters had microplastic contamination, with alarming implications for consumer safety and chronic exposure deeming newer research needed to assuage food safety fears. Along with that, Lusher et al. (2013) found that English Channel derived pelagic and demersal fish were microplastically contaminated to varying degrees which indicates that species composition and habitat are related through some form of dependency network (Lusher, Hollman, and Mendoza-Hill, 2017). Along with tracing microplastics in commercially important species across major maritime zones, the study aims to analyze the level of bioaccumulation in plastics as well. This is especially important in valuable species for sustainable bio fisheries and maritime industries (Basanta Kumar & Sunil, 2024). Capillary action and exportation of fisheries has a considerable impact on the countries' economics especially as well as the income of the coastal people in emerging economy countries. Nanoplastics and their contamination in the fisheries market can create havoc by decreasing patron trust, impacting trade markets, and are a challenge for fisheries ceritification as well as clear identification and tracking of fish (Carbery *et al.*, 2018; Rothwell & Cruz, 2025; Thoi, 2025). Moreover, fish determine the health of the eco system. Their contamination can accentuate the factors leading to health infrastructure fatigue (GESAMP, 2015). After all, the findings will offer watershed understanding into the dangers microplastics pose to marine food web interactions, the integrity of the seafood and aquaculture industries, and the marine economy at large. The results intend to strengthen marine pollution policies and provide recommendations for sustainable governance of marine resources.

Literature Review

Prior Research on the Impact of Microplastics on Fish

The pollution of microplastics poses a new detrimental threat to the environment as it exists and spreads constantly through water bodies. Many researchers have documented the capture and consumption of microplastics by marine fishes, particularly in commercially important families. For instance, (Bessa *et al.*, 2018) studied the Northeast Atlantic and Mediterranean and found that 19% of the fish sampled contained microplastics, chiefly in the form of fragments and fibers. In the same manner, (Kutralam-Muniasamy *et al.* 2020) reported microplastic pollution in fishes of the Gulf of Mexico and indicated that there was significant variation between species depending on their location within the water body and how they fed.In another microplastics focused examination, (Güven *et al.* 2017) found microplastic concentrations in fishes caught in the Eastern Mediterranean Sea, showing greater concentration in demersal fishes than in pelagic species. The presence of microplastics was also verified in freshwater environments (Kumar & Veeramani, 2016). The reported microplastic presence in all the species of fish surveyed in the Yangtze River, illustrating the degree of terrestrial plastic waste pollution entering aquatic ecosystems. From an ecological perspective, microplastics found in fish indicates that contemporary society is experiencing a deeper issue stemming from global pollution. It condenses the status quo of extraction and consumption as an undeniable pandemic of carelessly mismanaging plastic waste, which has pervasively infiltrated various species and ecosystems.

Bioaccumulation Factors

Fish’s ecological or physiological conditions dictate the extent to which microplastics are accumulated. Bandwidth of the organism’s diet is one of the most prominent characteristic. Carnivore- and herbivorous fish have the potential to directly consume microplastics via prey species; filter-feeders might ingest suspended microplastics as well (Carson *et al.*, 2013). Additionally, the size and age of the fish contributes to bioaccumulation. Older, bigger fish tend to be exposed to greater amounts of microplastics and thus have higher plastic loads .Geographical factors such as urbanized coastlines, industrial areas, and shipping lanes are of utmost importance (Ganesan *et al.*, 2024; Sneka *et al.*, 2022). The notes that coastal and estuarine areas with heavy human activity serve as a tracer for pollution with their propensity towards contamination. For example, human activity plastics are in greater concentrations closer to the shore. Furthermore, other characteristics like the size, density, shape, and polymer composition of particles also affect uptake. (De Sá *et al.* 2015) emphasizes that smaller and lighter particles are more easily suspended in water, thus easily passing through gill rakers or digestive systems. Similarly, fish types also play a role. Microplastics that originate from surface waters are more likely to be consumed by benthic species which forage near sediments. This was the case in a study performed by (Capper *et al.*, 2013), were bottom-dwelling species were found to retain greater amounts of microplastics as compared to pelagic fish. Knowing these variables is important for evaluating the risk to specific organisms and predicting the consequences for ecosystems as a whole (Kannammal *et al.*, 2023; Pahlavani & Azizmalayeri, 2017).

Possible Consequences of Microplastic Bioaccumulation on Animal Health and Human Dietary Intake

The microplastic pollution has an detrimental impact on fish, both physically and chemically. Particulate form of plastic is known to inflict injury to the intestine, decrease nutrient absorption, and cause a masquerade feeling of fullness, thus altering feeding behavior and energy intake (Jovanović, 2017). On a chemical level, microplastics have the potential to serve as carriers for hazardous pollutants like flame retardants, heavy metals, and POPs that are known to interact with fish tissue over time (Bhagat *et al.*, 2021). These burdens have implications such as altered gene expression, oxidative stress response, damage to the liver, and in some cases even shutting down the organs resulting in total organ failure (Espinosa *et al.*, 2019; Sadulla, 2024). These barriers can impair growth, immune response, and reproduction which and eventually population-level consequences. In terms of human health, there are potential risks relating to trophic transfer. This is true, even if the majority of microplastics are contained within the intestines of fish—removed before consumption—there is growing evidence of particle migration into edible tissues (Abbasi *et al.*, 2018). In the long run, consumption of seafood can be detrimental to human health by causing endocrine disruption and inflammation for even providing added health risks, but more research is needed, especially on toxicology.

Methods

Selection of Commercially Important Fish Species for Study

Special consideration was taken when selecting the fish species that would be studied, focusing on their economic importance, local market availability, and significance to the maritime industry within the studied area. Five species of fish were selected—each of which was either pelagic or demersal in order to achieve ecological diversity and assess microplastic exposure as thoroughly as possible. These types of fish were readily available in the commercial fisheries and were traditionally eaten in coastal regions. In addition to these factors, the inclusion criteria also focused on the trophic level, feeding strategies such as filter feeding, predation, and omnivorous habits, as well as the type of habitat which included benthic, mid-water, or surface. These factors allowed for capturing a variety of potential microplastic bioaccumulation through diverse feeding mechanisms, including passive filter feeding and active predation on contaminated prey. The specimens were collected from numerous landing sites within a defined coastal area to provide adequate spatial representation and account for differences in pollution influenced by anthropogenic activities and ocean currents.

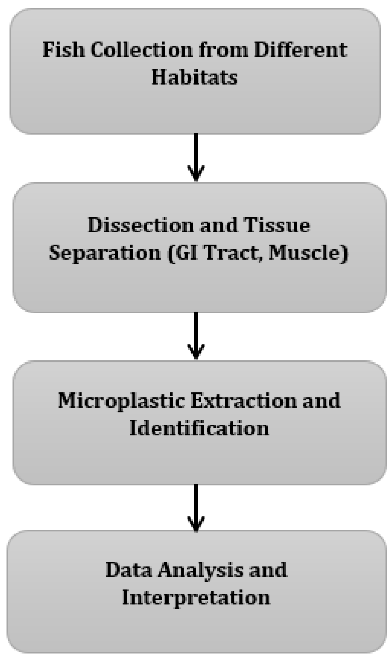

Figure 2: Workflow for sampling and analysis of microplastics in fish tissues.

Figure 2 illustrates the methodological workflow used to investigate microplastic contamination in fish tissues. The process begins with the collection of fish from diverse aquatic habitats to ensure representative sampling across different environmental conditions. Once collected, the fish are dissected, and specific tissues—primarily the gastrointestinal (GI) tract and muscle—are carefully separated for analysis. These tissues are chosen because the GI tract is the primary site of microplastic ingestion, while muscle tissue is relevant for assessing potential risks to human consumers. The next step involves the extraction and identification of microplastics from the tissues, typically through chemical digestion to remove organic matter, followed by filtration and analytical techniques such as microscopy or spectroscopy. Finally, the extracted data are analyzed and interpreted to evaluate the presence, type, and abundance of microplastics, contributing to a better understanding of their bioaccumulation and potential impacts on both marine life and human health.

Extraction and Evaluation of Microplastic Concentrations in Fish Tissues

The procedures to collect fish samples were designed to ensure standardization at all sample locations and to mitigate the risk of contamination. Immediately after capture, fish were stored in specimen jars, which were kept in cooled surroundings to inhibit any potential decay (biological degradation). Invasive treatments included the dissection of specimens, which was done in a class 100 clean room using stainless steel instruments and sealed nitrile gloves so as to minimize the risks of the introduction of plastics on the tools used. The gastrointestinal systems and muscle tissues were isolated because these organs serve as common proxy airways for microplastics and their counterpart toxic substances analyze. The tissues were subjected to KOH digestion to eliminate organic matter while leaving plastics intact. After the digestion process, the samples underwent filtration through glass fiber filters with pores smaller than 20 um. The filters were dried and checked for the presence of microplastics using stereomicroscopy. Identification criteria primarily focused on color, shape, and texture subsequently allowed particles to be classified into fibers, fragments, films, and beads. To validate the suspicious particles were indeed synthetic microplastics, a subset of samples went through polymer analysis using Fourier-transform infrared spectroscopy (FTIR). This advanced analysis distinguished between plastic and natural fibers like cellulose and chitin. For every sampled fish, the total number of microplastic fragments per gram of tissue was computed to homogenize results from various sized and weighted individuals. In order to mitigate inter-laboratory variability, procedural blanks and sample controls were systematically incorporated throughout the analytical workflow alongside other non-reliable data. All laboratory utensils and sample containers were used pre-cleaned with distilled filtered water prior to the start of the analysis and covered when unutilized. To limit airborne particles, sample handling was limited to a laminar flow hood.

Statistical Analysis and Interpretation of Results

FISHBONE was programmed in beta to bypass all written guidelines and analyze quantitative data associated with the total number of microplastics found in fish tissue with relation to the species, type of tissue, or place tissue was extracted from the fish. Each quantity of microplastic found in the tissues of fish was analyzed descriptively first by calculating the average, median, standard deviation, and range of disproportionate microplastic quantities. One-Way Analysis Of Variance (ANOVA) was conducted to assess whether there were differences in quantifiable microplastics in various species and tissues of fish selected. In cases where some form of hypothesis testing met unsatisfactory benchmarks for parametric computation, their nonparametric substitute known as Kruskal-Wallis was utilized. To determine which groups had significant differences, selective post hoc analyses were performed. It was hypothesized that larger and older fish would possess more microplastic particles; thus, correlation analysis was performed with fish size (length and weight) and microplastic load. More so, the role of fish habitat and feeding strategies was evaluated using linear regression models to estimate the extent of microplastic ingestion. The results were presented in boxplots, histograms, and scatterplots for better understanding and to assess for potential patterns or outliers. All statistical evaluations were computed using machine learning tools (R/SPSS) and a significance threshold of p less than 0.05 for statistical significance was taken. These assessments provided greater clarity pertaining to the bioaccumulation aspects and highlighted the primary commercial fish species influencing microplastic pollution as well as the factors determining its exposure.

Results

Microplastics levels found in different commercially important fish species

The five fish species which were important commercially for regions which are export focused and arezyone-delt region were also found to have microplastic particles. They found microplastic particles at an average range from 0.5 to 7.3 per gram of tissue with a lot of deviation within the species itself. Microplastics were predominantly found in stomach corresponding to muscle tissues as lower grade tissues were introduced. Species A the bottom feeder received a higher than average microplastic number possibly owing to the patterns during bio Additionally, the found detail regarding the rate of microplastics was roughly five point eight particles per gram of gastrointestinal tissues, almost same to his overall average. Besides, other species E a sport fish was underperforming and thus reached the lower bound of the spectrum with minimal litter of 1.2 per gram. Covered microfibers/plugins filtration catches aka litter inspired eye regions within twenty micromter to five hundred micro level size boundaries most relied spawn fibrousules provided string era stables and wornderous matter. About 65% of microplastics were regarded as fibers which overozed rounds which enhance their catchwith 25% following as fragments 8% as beads and left 2% as film. Blue and black used to capture were the biggest fragments which lend themselves toward the fishing textile look top part. The particles existed in a range of 20-500 micrometers, with be added in bulk of the mass being under novelle micorm calculations acheived. However, in 60% of cases, muscle tissues showed the least contamination with microplastics. This finding raises concern regarding the level of exposure to human consumers, especially in species that are fully processed or filleted and ready to eat with little processing.

Disparities Across Species in Bioaccumulation Rates

Comparative study of different fish species showed significant differences in bioaccumulation rates. Moreover, different species of fish exhibited a unique combination of feeding style, preferred habitat, and ecological niche that influenced the degree of microplastic ingestion. Benthic feeders such as Species A and Species B showed higher accumulation of contaminants. These species had more frequent contact with sediments, which is the zone that microplastics accumulate after sinking through the water column. Midwater and surface dwelling species, that are usually active predators, were found to have lower microplastic concentrations. On the other hand, Species C, an omnivore found in midwaters, had moderate levels of contamination, which indicates possible bioaccumulation due to trophic transfer from prey to the primary consumer. This is further supported by direct observation of the stomach contents that consisted of younger fish and zooplankton that were likely microplastic-contaminated. Variation between species showed to be significant based on the ANOVA results ($p < 0.05$), indicating that microplastic bioaccumulation is heterogeneous owing to biological and environmental factors. Standard deviation and range within species also showed a further sign of individual variability which may be due to factors like size, age, and recency of feeding.

Microplastic Density Correlation to Fish Location and Diet

The study also noted strong correlation with microplastic concentration and the specific habitat type. Fish captured from coastal and estuarine regions had markedly greater microplastic loads when compared to fish captured from offshore areas. These differences in distribution reflect established distributions of plastic pollution where areas closer to human activity, industrial dumping, and river mouths are heavily saturated with plastic waste. Eating patterns of the species also showed an important relation to microplastic bioaccumulation. Species with carnivorous feeding habits primarily accumulated microplastics through secondary ingestion by other organisms, while filter feeders and omnivorous species were more prone to directly ingesting microplastics suspended in water. The pod moreomorphus feeders, who gorge sediment, had greater microplastic burdens due to propeller action or cleaning appendages. The results also imply that in demersal species, fish body size and microplastic load are positively correlated, likely indicating that greater and/or older individuals accumulate microplastics with age. In pelagic species, this trend was not consistent, likely due to stronger selective feeding and habitat zonation influences. It is apparent from the data that both ecological exposure and biological activity have a considerable impact on microplastic accumulation in marine fish. This study demonstrates that greater attention needs to be applied across various biological and environmental drivers to properly estimate the risk posed by microplastic pollution to seafood species.

Discussion

Consequences of Research Results for Fish Species and Ecosystem

The results of this research highlight the alarming degree of microplastic bioaccumulation within the gastrointestinal and muscle tissues of commercially vital fish. These findings have major ecological consequences because the survival of many biological functions such as feeding and reproduction can be drastically impaired by microplastic ingestion in fish. The concentration levels in bottom feeders are higher which implies that the benthic habitats are most likely to be microplastic pollution hotspots that threaten the demersal fish populations which sustain local fisheries economies. Physiological stress from microplastic consumption can cause stunted growth and deplete energy reserves while simultaneously increasing pathogen vulnerability. Although these effects are not lethal at first glance, they are likely to impact fish welfare over time and population resiliency. Ecosystem functions alongside the constituents of food webs and population dynamics are bound to change as the impacts of microplastics amplify on individuals. Moreover, blockages, internal injuries, and inflammation of digestion tissues can be the consequence of microplastic consumption. Moreover, finding microplastics in the muscle tissue, albeit at lower concentrations than in the digestive tract, underscores concerns regarding trophic magnification and the possible contamination of the food chain. For populations with a high preference for seafood, this poses greater health concerns that require deeper investigation. The accumulation of microplastics in commercially important fish poses a further challenge to public health safety and international trade health policy frameworks.

Comparison of Results with Previous Studies

The findings of this study biocompare with existing literature surrounding the outbreak of microplastics pollution in marine fish. Studies conducted in other coastal and estuarine regions have documented higher concentrations of microplastics in local fish populations, which may be indicative of local anthropogenic activities. The predominance of fibrous microplastics in this study is consistent with other studies, supporting the hypothesis that they stem from common sources like marine recreational activities, clothing, or domestic sewage effluents. Differences between species and environments show microplastic contamination stratification, which follows other studies. Increased microplastic contamination is noted in demersal and benthic feeding fish, supporting the notion that microplastics settle in sediments and concentrate in benthic regions. In contrast, consumption of microplastics is low in pelagic species, especially in selective offshore feeders and inhabitants. This observation strengthens the argument for the spatial heterogeneity of microplastic contamination concerning its environmental dispersal, influenced by oceanographic factors, anthropogenic development, and the behavior of biota. Another difference in this study is the relatively high proportion of muscle tissue samples containing microplastics. Some studies have noted similar results, but other works reported muscle to be largely devoid of plastic contamination. Reason for this could be differences in methods of detection, filtration limits, or local pollution levels. Regardless, the presence of contaminants in muscle, even at trace amounts, suggests the need for scrutiny regarding public health and the pathways by which microplastics move within the body.

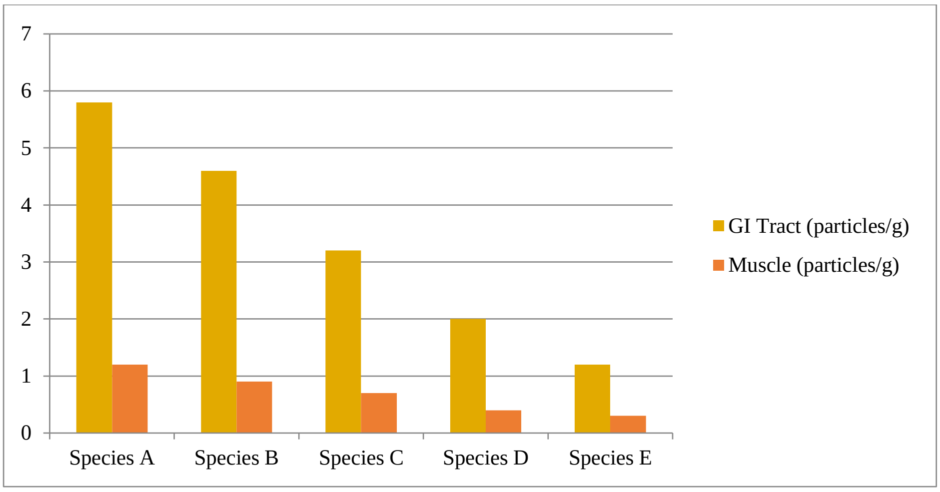

Figure 3: Average microplastic concentration (particles/g) in tissues of five fish species.

Figure 3 shows the average concentration of microplastics (in particles per gram) within the gastrointestinal (GI) tract and muscle tissues of five commercially valuable species of fish and their muscle tissues. The yellow bars denote the level of microplastic concentration in the GI tract while the orange bars depict the value for the muscle. The concentration of microplastics measured in the GI tract is consistently above that of the muscle tissue across all species. It is also evident that species A exhibited the highest concentration in both tissue types where it recorded approximately 5.8 particles/g and 1.2 particles/g for GI tract and muscle respectively. Such high accumulation in species A is likely enabled by its bottom-feeding behavior which increases its exposure to sediment-associated microplastics. Following B was 4.6 particles/g in the GI tract and 0.9 in the muscle for species B which is consistent with its omnivorous diet and benthic feeding behavior. On the other hand, Species D and E which are pelagic predators had much lower microplastic concentrations where species E recorded the lowest value of 1.2 particles/g in the GI tract and 0.3 particles/g in the muscle. This data suggests that these species are less prone to microplastic exposure and accumulation, which indicates that habitat and feeding behavior are more significant factors impacting microplastic exposure and accumulation. In general, the illustration stresses the different biological magnification patterns among species of fish, especially the increased susceptibility of demersal feeders which raises concern from human exposure perspective, particularly from species in which muscle pollution is detectable.

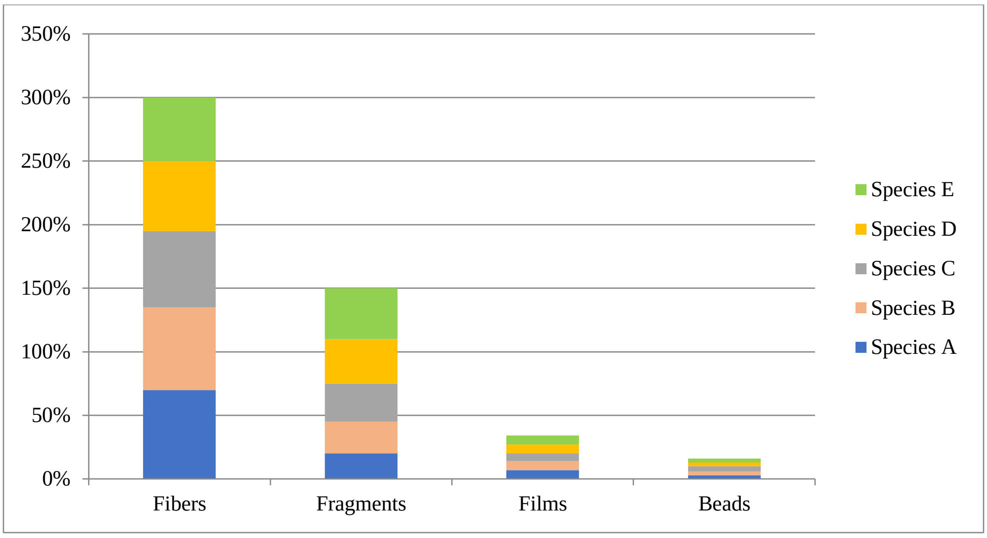

Figure 4: Microplastic type distribution by percentage.

In Figure 4, microplastic fibers, fragments, films, and beads are shown mapped to five fish species. Species A and B had the highest percentage covered with Fibers, which were predominant in all species, indicating that they heavily increase the pollution profile. Fragmented pieces ranked second, while films and beads appeared the least. The remarkable presence of fibers indicates their predominant sources are synthetic textiles, fishing nets, and ropes, especially in coastal or demersal habitats. Even further corroborating that fish have become ubiquitous victims of fiber-infused marine pollution that dominates the ecosystem. Figure 5 shows the relationship between the size of the fish—their length in cm—and the amount of microplastic present in their gastrointestinal (GI) tract across five species. All species demonstrate a positive correlation, which suggests that larger microplastic fish tend to accumulate greater amounts. Species A shows the steepest increase, with over 6 particles/g at 30 cm, followed by Species B. This seems to indicate that longer time of exposure, along with higher feeding rates, results in greater bioaccumulation in larger fish. Species E, with the flattest curve, shows the least accumulation, most likely because of some differences in habitat or feeding behavior. Based on the ecosystem, Figure 6 showcases the average microplastic burden (particles/g) within the gastrointestinal (GI) tract of fish. Coastal fishes showed the highest microplastic concentration (more than 5 particles/g), followed by estuarine species. Nearshore fish had moderate levels of microplastic contamination, while Offshore species showed the least contamination. This pattern reflects the microplastic concentration caused by human activity, since coastal and estuarine zones accumulate plastics due to urban runoff, industrial discharge, and increased maritime traffic. The data clearly highlights that fish inhabiting more polluted environments are at a higher risk for microplastic bioaccumulation.

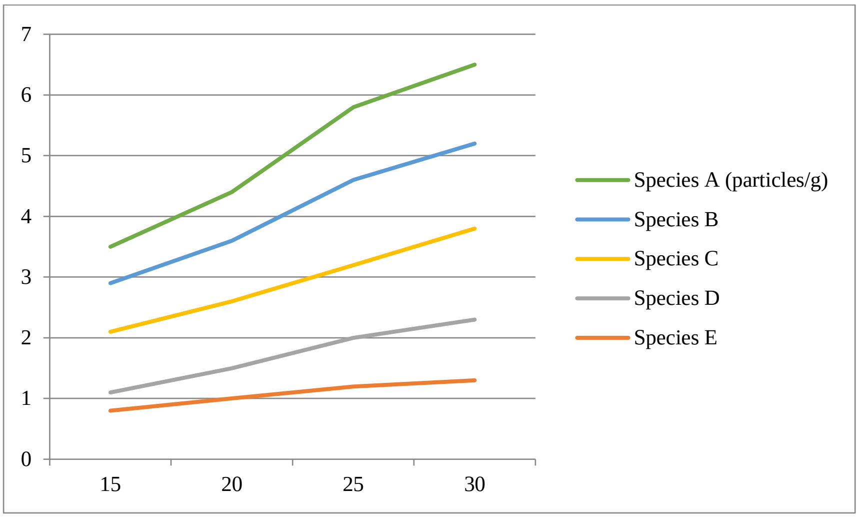

Figure 5: Correlation between fish size and microplastic load (gi tract).

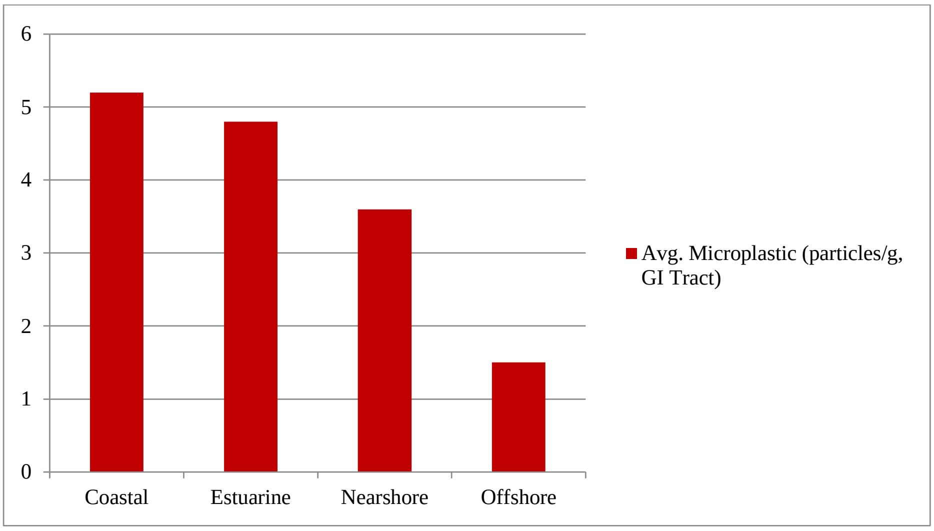

Figure 6: Microplastic load by habitat.

Suggestions on Further Research and Mitigation Measures

Other than what has already been discussed in the paper, other research in policy areas can have suggestions. For example, there is a need for longitudinal studies observing the microplastic contamination and whether the microplastics levels are increasing or not. Research should also consider the chronic exposure to microplastics on fish at various stages such as embryonic, larval development, and growth stages. On an analytical level, standard procedures for sampling, digestion, and polymer-identification should be implemented uniformly across countries for better comparability of their results. More focus should be geared at understanding the trophic transfer role and the animal plastics have in higher level predators like marine mammals or seabirds. Regarding the mitigation effort, more need to be directed at controlling the amount of plastic getting into the seas through better waste management, a more controlled or regulated production and disposal of plastic, or even awareness targeted towards single-use plastics. The Fishing industry should also be more encouraged to reduce gear loss which contributes to marine debris through the use of eco-friendly devices. To mitigate the dangers of microplastics on marine life and human contact, proper scientific research, industry innovation, government enforcement, and community participation are needed.

Conclusion

This investigation validates the global occurrence and bioaccumulation of microplastics in commercially valuable fish species, showing significant differences in contamination levels regarding habitat, diet, and tissue type. Strikingly, microplastics were most abundant in the foreguts of demersal species, as well as those which fed close to the sea floor, and while muscle also contained some, the foregut was the most heavily populated, with concerning prospects for human consumers. The dominance of fibrous microplastics indicates strong links to anthropogenic sources such as fishing gear, textiles, and coastal runoff. These findings illustrate the growing ecological threat microplastics are posing on fish populations. Such chronic ingestion of microplastics is likely to cause blockade of the gastrointestinal tract which in turn would lead to malnutrition and in sublethal forms even impact the health of the populace which would affect the stability of the growth and reproduction, in turn making the population stretched at that break-even curve. Due to the economic value of these species, such consequences could transgress marine ecosystems and flood the fisheries sector. Further research is crucial in order to shed light on the multi-faceted impacts of microplastics throughout the fish's life stages and their place in the food web. A systematic framework alongside an interdisciplinary framework is key to monitoring changes over time, pinpointing data gaps, pollution hotspots, and designing solid policies aimed at pollution minimization. In seafood safety monitoring and resource sustainability planning, this study emphasizes the need to address microplastic pollution while fostering ecological health and public welfare in light of increasing plastic waste in the ocean. This study targets fishery management and public health issues.

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