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ANALYSIS OF MICROPLASTIC ABUNDANCE IN THE DIGESTIVE TRACT OF FISH CAUGHT BY FISHERMEN IN THE PANGEMPANG WATERS OF EAST KALIMANTAN PROVINCE

Analisis Kelimpahan Mikroplastik pada Saluran Pencernaan Ikan Hasil Tangkapan Nelayan di Perairan Pangempang Provinsi Kalimantan Timur

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ABSTRACT

Microplastics are pollutants measuring less than 5 mm in size that are commonly found in sediments, water bodies, and aquatic biota. Microplastics can enter the bodies of marine biota, including fish. When fish are exposed to microplastics and consumed by humans in excessive amounts, this may affect human health. This study aims to analyse the types and abundance of microplastics in the digestive tracts of fish caught by fishermen in the waters of Pangempang, Muara Badak, East Kalimantan. The relationship between fish size and microplastic content is also investigated in this study. Fish samples consisted of six fish species (milkfish, baronang, gerot-gerot, snapper, kue, and trakulu) collected using random sampling. Microplastic analysis was conducted through organic destruction with H_2O_2 and $FeSO_4$, followed by microscopic identification. It was found that all fish digestive tracts contained microplastics, with the dominant type being fibres (97.4%), followed by films and fragments. Baronang fish had the highest microplastic abundance (11.0 particles/individual), while mangrove snapper had the lowest (2.33 particles/individual). The average abundance in omnivorous (8.125 particles/individual) was higher than carnivorous (5.2 particles/individual). There was a very weak correlation between fish size (length and weight) and microplastic abundance ($r<0.3$; $p>0.05$ in omnivores, $p<0.05$ in carnivores).

Keywords: Fish, Carnivores, Microplastics, Muara Badak, Omnivores

ABSTRAK

Mikroplastik merupakan polutan berukuran < 5 mm yang umum ditemukan di sedimen, perairan dan biota perairan. Mikroplastik dapat masuk ke tubuh biota laut, salah satunya ikan. Pada saat ikan terpapar mikroplastik dikonsumsi manusia secara berlebihan mungkin dapat mempengaruhi kesehatan manusia. Penelitian ini bertujuan untuk menganalisis jenis dan kelimpahan mikroplastik pada saluran pencernaan ikan hasil tangkapan nelayan di perairan Pangempang, Muara Badak, Kalimantan Timur. Hubungan antara ukuran ikan dengan kandungan mikroplastik juga dinvestigasi di penelitian ini. Sampel ikan terdiri dari enam spesies ikan (bandeng, baronang, gerot - gerot, kakap, kue dan trakulu) yang dikumpulkan menggunakan metode random sampling. Analisis mikroplastik dilakukan melalui proses destruksi organik dengan H_2O_2 dan $FeSO_4$, diikuti identifikasi mikroskopis. Ditemukan bahwa semua saluran pencernaan ikan mengandung mikroplastik, dengan jenis dominan adalah fiber (97,4%), diikuti film dan fragmen. Ikan baronang memiliki kelimpahan mikroplastik tertinggi (11,0 partikel/individu), sedangkan kakap bakau terendah (2,33 partikel/individu). Rata-rata kelimpahan pada omnivora (8,125) partikel/individu) lebih tinggi dibanding karnivora (5,2 partikel/individu). Terdapat hubungan yang sangat lemah antara ukuran (panjang dan berat) ikan dengan kelimpahan mikroplastik ($r<0,3$; $p>0,05$ pada omnivora, $p<0,05$ pada karnivora).

Kata Kunci: Ikan, Karnivora, Mikroplastik, Muara Badak, Omnivora

INTRODUCTION

Marine debris is man-made waste released into the oceans, either intentionally or unintentionally (Osman *et al.,* 2023). One type of debris found in water is plastic. Plastic in the marine environment can decompose into smaller particles due to exposure to sunlight, abrasion, seawater hydraulics, and oxidation (Sutkar *et al.,* 2023). Larger plastics can be destroyed and fragmented into nano- and micro-sized particles (Da Costa *et al.,* 2016). Microplastics are defined as being <5 mm in size (Hidalgo-Ruz *et al.,* 2012) and having a density lighter than water (0.917-2.3 g/cm^3), making them buoyant and easily carried by currents (Fleming *et al.,* 2014).

Microplastics can be categorized into two types: primary and secondary (Ikrar Jamika *et al.,* 2023). Primary microplastics are plastics intentionally produced in micro-sizes for specific purposes, such as raw materials for industrial plastics, cosmetic scrubs, and fibers in synthetic clothing. Secondary microplastics, on the other hand, are the result of larger, degraded plastic fragments. These are the types that often spread to various places and pollute the environment (Ragusa *et al.,* 2021). Fragmented microplastics often originate from household, commercial, and industrial activities, making them easily distributed throughout various ecosystems, even to remote areas (Dewi, 2022). Their flexible and easily dispersed nature makes microplastics frequently found in water, sediments, and biota (in fish, they are found in the gills, liver, and digestive tract) (Fitriyani *et al.,* 2025; Nelms *et al.,* 2019). The presence of plastic in water has the potential to cause physical effects, but when reduced to microplastic size, it can potentially cause chemical effects (Siddiqui *et al.,* 2023). Meanwhile, for biota, especially fish, microplastics can cause negative effects on their bodies, such as inflammation, stress, oxidation, and metabolic disorders (Lusher *et al.,* 2017).

One area in East Kalimantan that has been contaminated with microplastics is the waters of Muara Badak (Dewi *et al.,* 2015). This occurs due to the numerous human activities that produce plastic waste, such as household waste, fisheries waste, and the tourism sector (Rindyani *et al.,* 2024). This plastic waste can decompose into smaller meso- and microplastics due to physical and chemical weathering both on land and in water (Osman *et al.,* 2023). If these microplastics enter and accumulate in the bodies of aquatic organisms, such as fish, they can cause health problems such as decreased immunity, cell death (apoptosis), and DNA changes (Li *et al.,* 2024). Furthermore, fish contaminated with microplastics can impact human health, such as increasing oxidative stress, cell death, and impaired cell regeneration (Osman *et al.,* 2023). One approach to determining the presence of microplastics in fish is through research.

Research on microplastics is still very limited in Muara Badak. To date, information on microplastics has only been collected from sediments (Dewi *et al.,* 2015) and aquatic biota

(Ayun *et al.,* 2023). Therefore, further research is needed to determine the microplastic content in the digestive tracts of several fish species caught in the waters of Pangempang, Muara Badak.

RESEARCH METHODS

Place and Time

This research was conducted from August to December 2024, encompassing sampling, literature review, sample processing, and data analysis. The fishing and sample collection locations were in Pangempang waters, Muara Badak District, East Kalimantan Province (Figure 1).

Figure 1. Fishing location

Tools and Materials

Some of the tools used in this study were gloves (latex), 250 ml Erlenmeyer flask, distilled water, ball pipette, dropper, dry tissue, FeSO4 solution (0.05 M), H2O2 (30%), analytical balance (Ohaus brand), vacuum pump, Whatman filter paper (No. 41), aluminum foil, tweezers, aluminum cup, oven (Kelvin brand), measuring board, scalpel, scissors, microscope (Relife RL-M3T) and water bath. While the materials used in this study were 6 species of fish caught by fishermen.

Research Procedures

The research procedure began with the random sampling of 25 fish samples caught by fishermen in Pangempang waters, including milkfish, rabbitfish, snapper, snapper, and trakulu (Table 1). All collected fish were taken to the laboratory for further processing. The following day, each fish sample was measured for length (cm) and weight (g) and dissected to obtain its digestive tract (SP). The digestive organs were placed in sample bottles and labeled for each individual. Each SP sample was given 20 mL of 30% H_2O_2 solution and 2 mL of 0.05 M $FeSO_4$, and incubated for approximately 7 days to allow organic tissue to be destroyed. Afterward, the resulting digestion solution was filtered using 11 cm diameter filter paper to separate microplastic particles. The filter paper was dried at room temperature, then observed using a stereo microscope (microscopic) to identify the type and quantity of microplastics based on the book Guide for the Visual Identification & Classification of Plastic Particles (2024) for classification of forms (fiber, fragment, and film). Data on the abundance of microplastics in each fish species were calculated and analyzed, and a Spearman correlation test was performed to see the relationship between the size (length and weight) of the fish and the number of microplastics detected (Jabeen *et al.,* 2017).

Data Analysis
Abundance

The abundance of microplastics in this study was calculated by particles per species (abundance = number of plastic particles/number of fish species) based on research conducted by Fitriyani *et al.,* (2025).

$$Abundance = \frac{number\ of\ microplastic\ particles}{number\ of\ species}$$

Statistical Analysis

Statistical analysis was performed using the Spearman correlation test to determine the relationship between fish body length and weight and the abundance of microplastics in their digestive tracts. This test was chosen because the data were not normally distributed and were ordinal in scale. The correlation coefficient (r) and significance (p) values were used to assess the strength and direction of the relationship between variables. Interpretation of the r value refers to the classification of correlations: very weak (0.00–0.19), weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79), and very strong (0.80–1.00). The results of this test provide an overview of the extent to which fish body size influences the potential for microplastic exposure (Mustofani & Hariyani, 2023).

RESULT

Identification Results

This study found that all fish species analyzed contained microplastics in their digestive tracts. The identified microplastics came in three main forms: fibers, fragments, and films (Figure 2).

Microplastic Abundance Analysis

A total of 155 microplastic particles were found in all fish samples. The most abundant particles were fibers (151 particles), followed by films (3 particles), and fragments (1 particle) (Figure 3A). The analysis revealed the highest abundance of microplastics in rabbitfish (Siganus canaliculatus) with 11 particles per individual. The lowest abundance was found in mangrove snapper (Lutjanus johnii) with 2.33 particles per individual (Figure 3B).

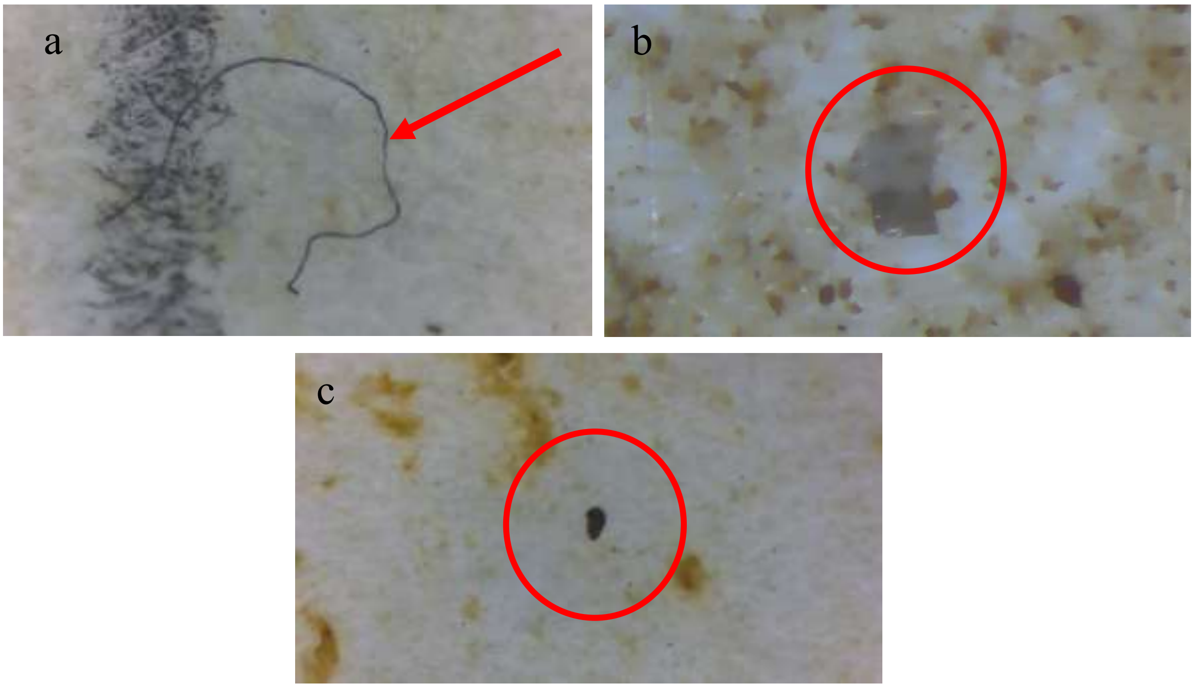


Figure 2. Microplastics of the fiber type (a), film (b), fragments (c) found in the digestive tract of fish (red circle) (10x magnification).

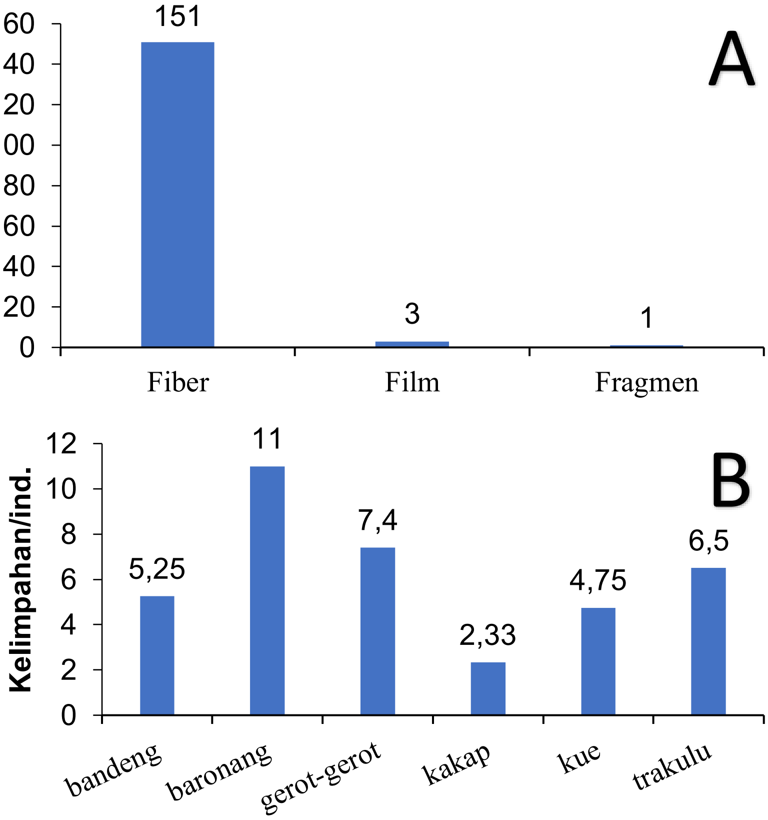
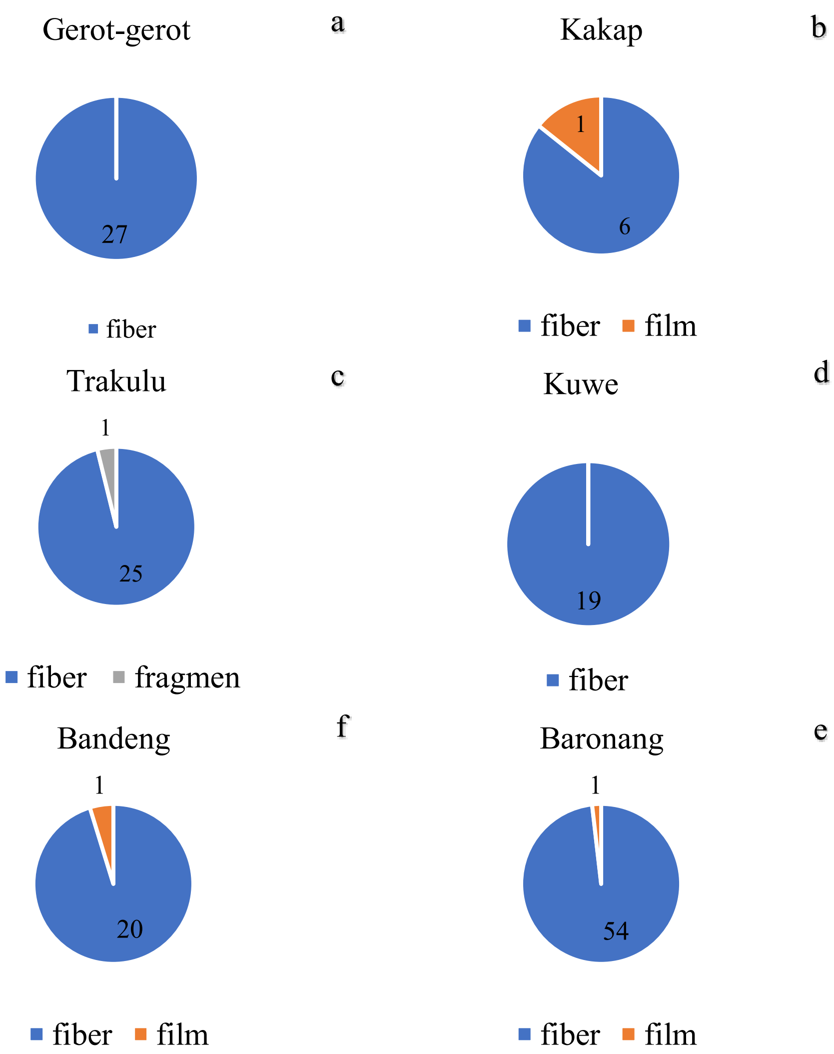


Figure 3. Number of microplastics per type (A), Number of microplastics per individual (B).

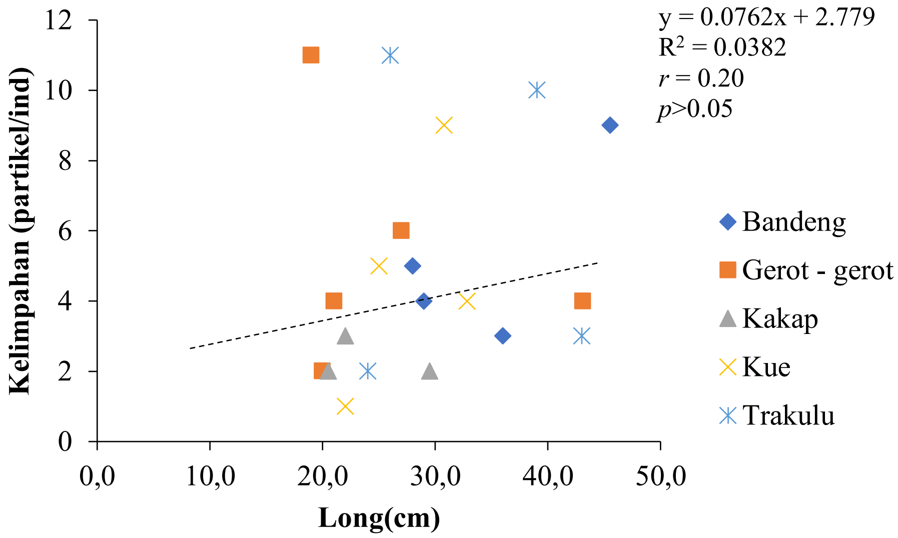
Based on the number of microplastic particle types per species, in the digestive system of the gerot-gerot, only 27 fiber particles were found. Then, in the snapper sample, 6 fiber particles and 1 film particle were found. In the trakulu sample, 26 fiber particles and 1 fragment particle were found. In the kue sample, only 19 fiber particles were found. In the milkfish sample, 20 fiber particles and 1 film particle were found. Finally, in the rabbitfish sample, 54 fiber particles and 1 film particle were found (Figure 4).



Gambar 4. Jumlah jenis partikel mikroplastik perspesies.

Correlation Between Microplastic Abundance and Fish Length and Weight

Spearman's correlation test results showed a weak and insignificant relationship between length and microplastic abundance in omnivorous fish ($r = 0.20$ and $p > 0.05$). Similarly, weight and microplastic abundance showed a very weak correlation ($r = 0.16$ and $p > 0.05$).



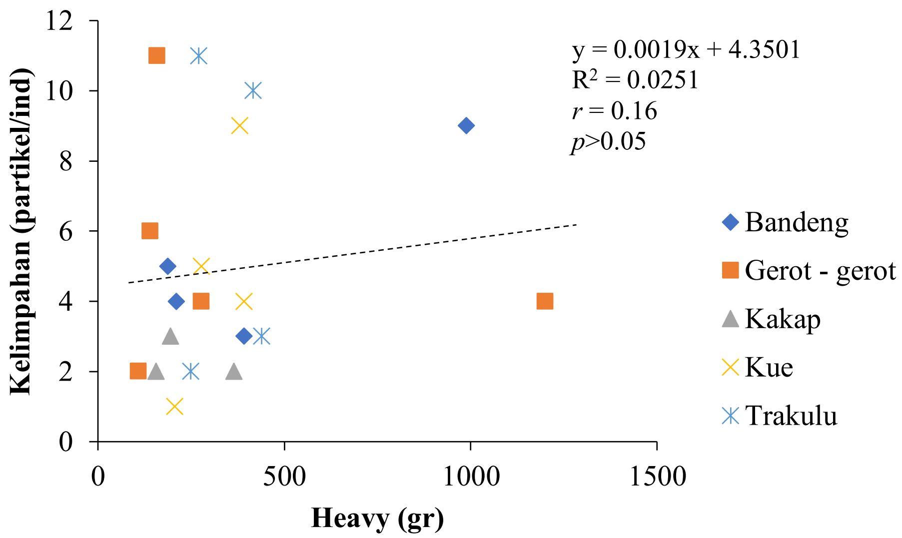


Figure 5. Relationship between fish weight and microplastic abundance.

Microplastic Abundance Based on Dietary Habits

When all fish species in this study were classified based on their feeding habits, both omnivorous and carnivorous fish were found. The fish with omnivorous diets in this study were milkfish (Chanos chanos) and rabbitfish (Siganus canaliculatus). Meanwhile, carnivorous fish consisted of the gorot-gerot fish (Pomadasys maculatus), snapper (Lutjanus johnii), kue fish (Caranx sp), and trakulu (Caranx papuensis). The analysis results showed that the highest average abundance of microplastics was found in omnivorous fish, at 8.13 particles per individual, while carnivorous fish had an average abundance of 5.20 particles per individual (Figure 6). This indicates that omnivorous fish tend to be more exposed to microplastics than carnivorous fish.

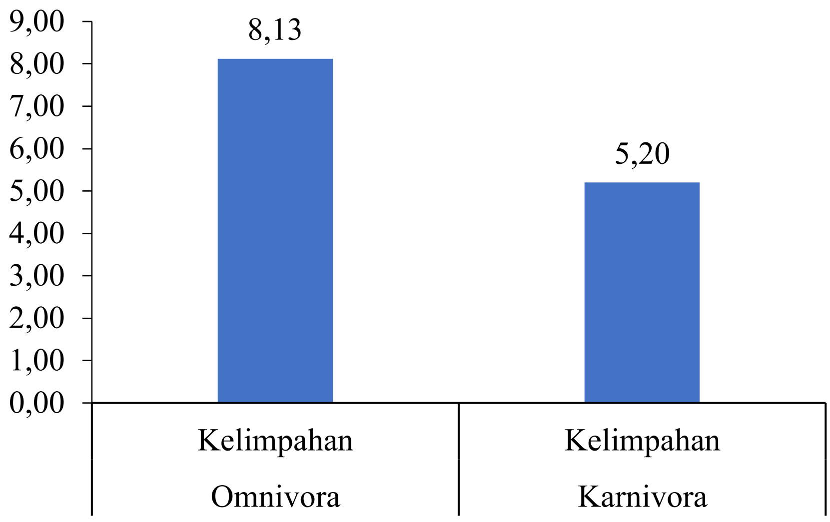


Figure 6. Comparison graph of microplastic abundance (particles/individual) in omnivorous and carnivorous fish.

Based on the results of a simple linear regression analysis, the relationship between microplastic abundance and fish size (length and weight) in omnivorous fish is weak, negative, and insignificant ($p>0.05$). This finding is inversely proportional to the relationship between microplastic abundance and fish size (length and weight) in carnivorous fish, which is weak, positive, but significant ($p<0.05$). These findings indicate that microplastic abundance in carnivorous fish tends to increase with body size.

Microplastic Color

The results of observations on the color of microplastics found in the digestive tract of fish show that the most dominant color is black (79%), followed by red (10.6%), blue (9.6%), clear (8.5%), white (5.3%) and green (1.1%) (Figure 7).

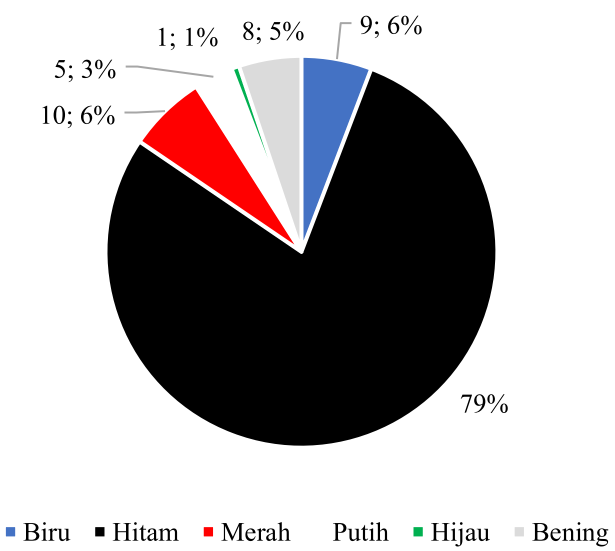


Figure 7. Percentage of microplastic color

DISCUSSION

The study found that microplastics found in the digestive tract (GI) of the six fish species studied consisted of fibers, films, and fragments. Fibers are a type of microplastic that resembles fibers and originates from various sources, such as clothing, fishing gear, boat construction materials, and others (Dewi *et al.,* 2015). This type of microplastic is often found in coastal areas due to its source being closely associated with fishing activities and its proximity to fishermen's activities. Its flake-like shape and clear color make it difficult to detect in nature. Therefore, this type of microplastic has the potential to be accidentally ingested or consumed by fish (Dewi, 2022). Fragmentary microplastics typically originate from difficult-to-decompose plastics, such as beverage packaging, furniture and glassware, and electronic product shields. Due to its domestic origin, this finding is suspected to be waste from residential areas near the sampling point (Ragusa *et al.,* 2021). The presence of microplastics in the digestive tracts of all fish species analyzed indicates that microplastic pollution in Pangempang waters has reached alarming levels. The predominance of fiber-shaped microplastics (97.4%) indicates that the primary sources of pollution likely come from household waste, fishing gear such as nets and ropes, and textile industry activities. Fiber is generally the most common type of microplastic found in marine organisms due to its lightweight and durable nature in aquatic environments.

Among the fish species analyzed, the rabbitfish (Siganus canaliculatus) showed the highest abundance of microplastics, while the mangrove snapper (Lutjanus johnii) had the lowest abundance. This difference is likely related to variations in feeding behavior and habitat preferences of each species. Omnivorous fish tend to forage more widely across various trophic levels and habitats, increasing the risk of ingesting microplastics, either directly or indirectly through prey. Conversely, carnivorous fish, which primarily prey on fish or other large organisms, are less likely to ingest microplastics, although not entirely risk-free.

Based on the results of the Spearman correlation test on five fish species (rabbit fish were not subjected to regression analysis), the correlation between microplastic abundance and fish length was 0.20 and was not significant ($p>0.05$) (Figure 24). This correlation value, which is close to zero, indicates a very weak but positive relationship between microplastic abundance and fish size. This finding indicates that microplastic abundance in the digestive tract (GI) of fish can increase with increasing fish size (length and weight). Therefore, this study recommends that fish consumers remain cautious when consuming large-sized GI fish from Pangempang waters, Muara Badak, to avoid microplastic exposure. One possible measure to avoid microplastic exposure is to avoid consuming GI fish caught in Pangempang waters. The high microplastic content in omnivorous fish (milkfish and rabbitfish) is thought to be due to their more varied diet, which includes insects, microshrimp, phyto- and zooplankton, microscopic plants, seagrass, micro- and macroalgae, detritus, protozoa, and crustaceans (Djumanto *et al.,* 2017; Indriyani *et al.,* 2020), which may have been exposed to microplastics. Furthermore, omnivorous fish typically live and forage in shallow waters or near the bottom where microplastics accumulate more (Liang *et al.,* 2023). Meanwhile, carnivorous fish generally eat larger prey such as small fish and shrimp, which have a lower chance of directly ingesting microplastics.

Based on Spearman's correlation, the abundance of microplastics in carnivorous fish tends to increase with body size. Therefore, consumers should be cautious when consuming carnivorous fish from Pangempang waters, especially large fish. In general, the results of this investigation differ from those found by (Ayun *et al.,* 2023) and (Aliyansyah & Holil, 2024) in Sidoarjo Regency, where fish with omnivorous diets tended to contain more microplastics than carnivorous fish. These findings indicate that dietary habits are a significant factor in determining the level of microplastic exposure in marine biota. Therefore, understanding fish dietary habits is crucial in assessing the risks of microplastics, both ecologically and from a food safety perspective for humans, particularly in Muara Badak.

The results of this study indicate that the most dominant microplastic color in this study was black (79%). In general, the dominance of black in microplastics in this study is relatively similar to the results of research at the Belawan Fish and Fish Farm (TPI Belawan), where black (92%) was found in the gills and digestive tract of mackerel (Rastrelliger sp) (Erlangga *et al.,* 2022). The high percentage of black and red in this study may be related to the fish's dietary patterns. Several studies have shown that fish tend to be attracted to microplastics that resemble their natural food, such as plankton or fish eggs (Aryani *et al.,* 2024). Fish's visual preference in recognizing food often leads them to mistake microplastics for their natural prey based on their color. Certain species, such as surface fish, may be more likely to ingest floating, strikingly colored plastic. Meanwhile, fish that are active at night or on the seabed may be less influenced by color, but more by the shape of the microplastic (Tobing *et al.,* 2020).

CONCLUSION

Three types of microplastics were found in the digestive tracts of six fish species caught in the waters of Pangempang, Muara Badak: fiber, film, and fragments. A total of 155 particles were found in the 25 fish samples: 151 fiber particles, 3 film particles, and 1 fragment particle. The correlation between fish size and the abundance of microplastics in the digestive tract (SP) of several fish species was very weak and insignificant ($p>0.05$). Omnivorous fish (8.13 particles/individual) had a higher abundance of microplastics than carnivorous fish (5.20 particles/individual).

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