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IDENTIFICATION OF MICROPLASTIC ABUNDANCE IN SEDIMENT AND KUWE FISHES (*Caranx sp.*) IN THE COASTAL AREA OF GAMPONG JAWA BANDA ACEH

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ABSTRACT

The presence of microplastics in aquatic sediment is a threat to biota that live in waters, especially fishes. This study aimed to identify the presence of microplastics in sediment and Kuwe fishes (*Caranx sp.*) in the coastal waters of Gampong Jawa Banda Aceh. This research processes began with sampling, sample preparation, microplastic identification, and Fourier Transform Infrared Spectroscopy (FT-IR) testing to determine the type of polymer as the origin of the microplastics in the fish samples. Several types of microplastics were identified as fragments, fibers and films. It was found the microplastic colors were brown, transparent, black, blue and red. The abundance of microplastics found in sediment was 1630 particles/kg, while in fish digestive tracts was 975 particles/kg and in the fish bodies was 135 particles/kg. The results of FT-IR analysis have verified several types of polymers such as Polypropylene (PP), Polystyrene (PS), Poly (methyl methacrylate), Ethylene Vinyl Acetate (EVA), Nylon, High-Density Polyethylene (HDPE), and Low-Density Polyethylene (LDPE), with appropriate functional groups. The discovery of microplastics in the coastal waters of Gampong Jawa Banda Aceh indicates microplastic contamination. Therefore, preventive efforts are needed to reduce the abundance of microplastics in these waters.

Keywords : Microplastic, Abundance, Sediment, Kuwe Fish, FT-IR

ABSTRAK

Kehadiran mikroplastik dalam sedimen akuatik merupakan ancaman bagi biota yang hidup di perairan, terutama ikan. Penelitian ini bertujuan untuk mengidentifikasi keberadaan mikroplastik dalam sedimen dan ikan Kuwe (Caranx sp.) di perairan pesisir Gampong Jawa Banda Aceh. Proses penelitian ini dimulai dengan pengambilan sampel, persiapan sampel, identifikasi mikroplastik, dan pengujian Spektroskopi Inframerah Transformasi Fourier (FT-IR) untuk menentukan jenis polimer sebagai asal usul mikroplastik dalam sampel ikan. Beberapa jenis mikroplastik yang telah teridentifikasi adalah fragmen, serat, dan film. Warna mikroplastik yang ditemukan adalah coklat, transparan, hitam, biru, dan merah. Kelimpahan mikroplastik yang ditemukan dalam sedimen adalah 1630 partikel/kg, sementara dalam organ pencernaan ikan adalah 975 partikel/kg dan dalam tubuh ikan adalah 135 partikel/kg. Hasil analisis FT-IR telah memverifikasi beberapa jenis polimer seperti Polipropilena (PP), Polistirena (PS), Poli (metil metakrilat), Etilen Vinil Asetat (EVA), Nilon, Polietilena Densitas Tinggi (HDPE), dan Polietilena Densitas Rendah (LDPE), dengan gugus fungsi yang sesuai. Penemuan mikroplastik

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di perairan pesisir Gampong Jawa Banda Aceh menunjukkan kontaminasi mikroplastik. Oleh karena itu, upaya pencegahan diperlukan untuk mengurangi kelimpahan mikroplastik di perairan ini.

Kata kunci : *Mikroplastik, Kelimpahan, Sedimen, Ikan Kuwe, FTIR*

Introduction

Plastic waste has become an urgent global environmental issue, with serious impacts on marine ecosystems and human health. Indonesia, as the country with the second highest production of plastic waste in the world, encounters significant challenges in managing and reducing its negative impacts. Data from the Indonesian Plastics Industry Association (INAPLAS) and the Central Statistics Agency (BPS) in 2022 show that Indonesia produces about 64 million tons of plastic waste per year, with approximately 3.2 million tons contaminating the oceans. Previous research has revealed that about 14 million tons of plastic enter the oceans each year, accounting for up to 80% of total marine debris (International Union for Conservation of Nature, 2021).

The degradation process of plastics in water leads to the formation of microplastics, approximately 0.3-5 mm in size, influenced by some factors such as wind, ocean waves, and animal activity, posing serious risks to ecosystems and marine biota (Febriani et al., 2020; Kershaw, 2015). The impact of microplastics on marine biota includes damage to the digestive tract, growth inhibition, and reproductive disruption, which can lead to declines in population and diversity of marine species. Microplastics also have the potential to enter the human food chain through fish and seafood, posing health risks such as lung inflammation and respiratory disorders (Supit et al., 2022; Bengalli et al., 2022; Tomonaga et al., 2024).

In Indonesia, research on the distribution and impact of microplastics, especially in coastal areas such as Gampong Jawa Beach in Banda Aceh is currently still limited. Human activities such as plastic waste disposal and tourist visits increase potential risk of microplastic contamination in the waters. This study aimed to identify the abundance of microplastics in sediment and Kuwe fishes (*Caranx sp*.) in the Coastal waters of Gampong Jawa Beach, Banda Aceh, using purposive sampling methods (Seftianingrum et al., 2023). Through this research, it is hoped that an understanding of the abundance and characteristics of microplastics in research area can be obtained. This information can then strengthen the understanding about Indonesian coastal waters as well as be part of references for the policies in protecting coastal environments from plastic pollution.

Methods

This research took place in the coastal waters of Gampong Jawa, located in the Kuta Raja Subdistrict, Banda Aceh. The sediment sampling was conducted at three predetermined coordinate points, namely T1 (5.583019°, 95.312067°), T2 (5.583295°, 95.311755°), and T3 (5.583778°, 95.311461°). It can be seen in Figure 1. The selection of sampling points was conducted by using the purposive sampling method, where points T1, T2, and T3 were taken at varying distances from the shore to later be used for comparison. Sediment samples were collected using a Sediment

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Grab, by following the method performed by Satria et al. (2017). While fish sampling was carried out not at fixed points but in the area around the research location. The fish samples were collected the local fishermen which were netted around the locations of the sediment sampling. Samples of Kuwe fish were collected from the catch of local fishermen around the research area. Parts of the fish that were collected included the body and digestive organs, which were needed for subsequent observation (Rocman, 2015).

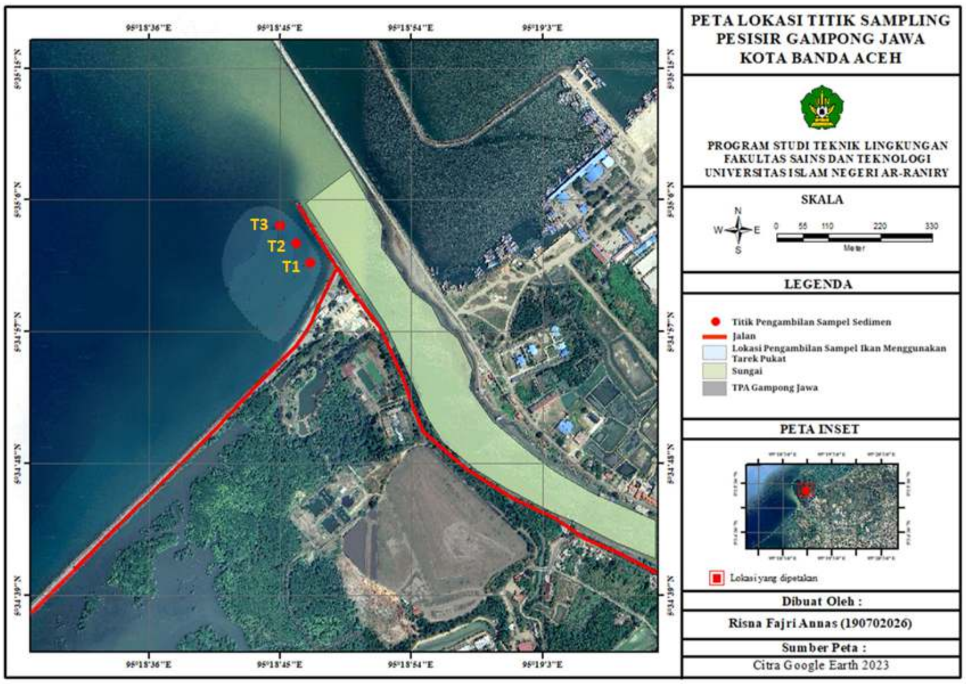

Figure 1. Sampling points of sediment

Sediment samples were first prepared, and then analyzed by observing under binocular microscope to identify microplastics in terms of number, color, shape, and size with a magnification of 10 x 4.5 (Kapo et al., 2020). Similarly, fish samples were also prepared before being observed under a binocular microscope. The microplastics found in the fishes were tested using Fourier Transform Infrared Spectroscopy (FT-IR) to determine the functional groups and types of plastic polymers.

Results and Discussion

1. Microplastic Abundance

a. Microplastic abundance in sediment

The abundance of microplastics in sediment samples can be seen in Table 1.

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Table 1. Microplastic abundance in sediment

Samples of Sediment				
Sampling Points	Types of Microplastic			Microplastics (particles/kg)
	Fragment	Fiber	Film	
T1	21	3	1	25
T2	30	15	2	47
T3	80	7	4	91
Abundance	**131**	**25**	**7**	**163**

The research found that the microplastics were more abundant at location T3 than at T2 and T1, because the T3 location are closer to the mouth of river estuary than T1 and T2. Beside fragments, fiber-type microplastics were found in significant number, especially at location T2 with 15 particles per kilogram. The fibers are presumed to originate from remnants of fishing gear used on the beach in Gampong Jawa, Banda Aceh. Furthermore, film-type microplastics come from broken plastic bags or wrappers commonly used by locals or tourists to package food. The limited detection of film microplastics in sediment could be due to their low density, making them more easily transported by ocean currents (Kapo, 2022).

b. Microplastic abundance in fish

The abundance of microplastics in fishes can be seen in Table 2.

Table 2. Microplastic abundance in fish samples

Samples of Fishes					
Sampling Location	Fish Parts	Types of Microplastic			Microplastics (particles/kg)
		Fragment	Fiber	Film	
Around the area	Fish's Body	13	48	4	**65**
	Fish's Digestive Tract	58	15	5	**78**
Abundance		**71**	**63**	**9**	**143**

In this study, the organs observed in fish were divided into two parts, they were the digestive system and the body of the fish. The most microplastic-containing organ was the digestive tract, where it contained 78 particles/kg. Microplastics enter the fish's digestive system through their feeding activities, either indirectly through the ingestion of contaminated food or directly. Over the time, these microplastic particles can accumulate in the digestive tract (Rochman et al., 2015). Meanwhile, the number of microplastics found in the body of the fish were 65 particles/kg, with fibers being the most dominant type originating from fishing gear. Factors such as absorption, distribution, accumulation, and changes in trophic levels affect how much microplastics accumulate in the fish's body (Senduk et al., 2021).

2. Characteristic of Microplastic

a. Types of Microplastic in sediment

The types of microplastics found in the sediment can be seen in Table 3.

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Table 3. Types of microplastics found in sediment

No	Types of Microplastic	Pictures	Remarks
1	Fragment		Shaped like fragments and have a solid texture
2	Fiber		Shaped like threads or fishing nets
3	Film		Flexible, thin particles with low density

The types of microplastic found in the sediment samples were fragments, fibers, and films. Fragments had sizes ranging from 40,149.31 µm², fibers from 762.86 µm, and films were sized at 29,078.19 µm². The size of the microplastics varies significantly, influenced by the degradation processes of microplastics in the waters. Microplastics tend to decrease in size over time due to the fragmentation process in water (Azizah, 2020). Some factors that affect the size and shape of microplastics were UV rays, sea waves, the oxidative nature of plastics, and the hydrolytic characteristics of seawater (Wahdani et al., 2020). The results of this study are also presented in a graph that shows the number of microplastic shapes found (Figure 2).

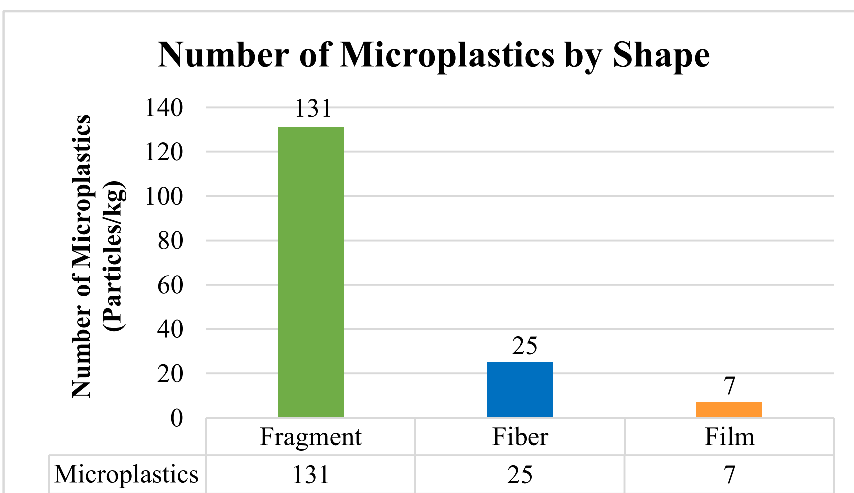

Figure 2. Number of microplastics by shape in sediment samples

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The most common type of microplastic found was fragments, with a total of 131 particles. Fiber-shaped microplastics were the second most common, with 25 particles, while film-shaped forms were the third most common with 7 particles. Plastic fragments originate from objects such as discarded plastic bottles that end up in the sea, including beverage bottles and packaging from ready-to-eat meals that are solid (Ayuningtyas et al., 2018). Fiber-shaped microplastics come from nets commonly used by fishermen when catching fish with nets or other fishing gear (Crawford et al., 2017). Meanwhile, film-shaped microplastics come from plastic bags often used by tourists when purchasing food. This aligns with the findings of Sarasita et al. (2020), who noted that film-type microplastics often originate from plastic bags and transparent food or beverage packaging with low density, thus tending to float on the water surface. The differences in shape and size of these microplastics are influenced by various factors, including the base materials of the plastics themselves, the fragmentation processes in the water, and environmental factors such as UV radiation exposure, waves, climate change, and other abiotic factors.

b. Colors of Microplastics in Sediment

The study on sediment samples found microplastics in a variety of colors, which can be seen in Figure 3.

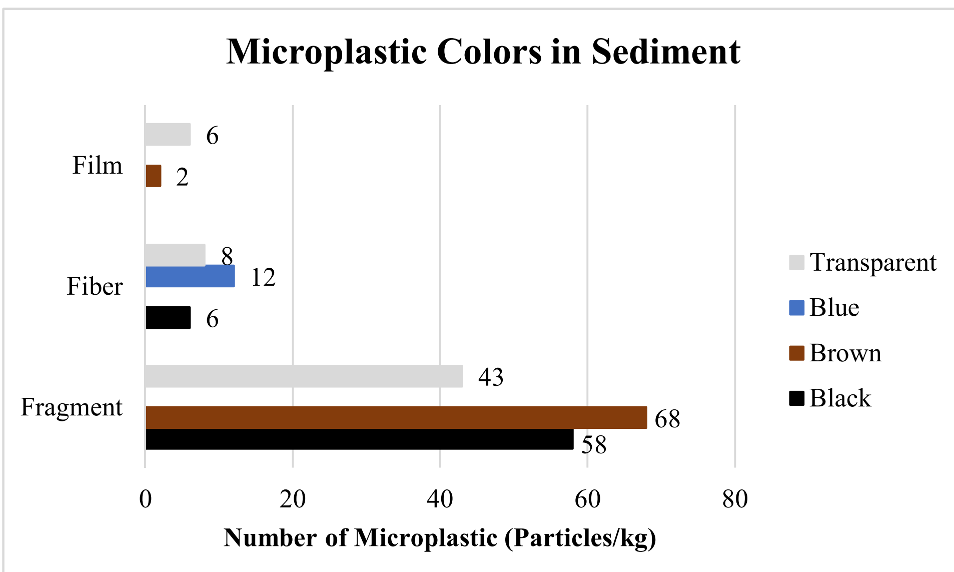

Figure 3. Microplastics by color in sediment samples

The majority of the microplastics found were brown, particularly the fragments, followed by black and transparent. Blue microplastics were not found in the samples. The brown color in the microplastic fragments is caused by the degradation of plastic materials exposed to sunlight and oxygen, as well as the influence of organic compounds, minerals, and oxidative conditions in the water. The most commonly found fiber microplastics are blue, due to their fiber characteristics resembling fishing nets and their reaction to ultraviolet light (Azizah et al., 2020).

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The black and brown colors in microplastics originate from materials capable of absorbing pollutants and heavy metals in the water. Meanwhile, the transparent color indicates that the microplastics have been contaminated for a long time and have undergone photodegradation (Ridlo et al., 2020).

c. Microplastic Shapes in Fish

The shapes of microplastics found in fish can be seen in Table 4.

Table 4. Shapes of microplastics found in fish

No	Types of Microplastic	Observed Organ (Fish Body)	Observed Organ (Digestive Tract)
1	Fragment		
2	fiber		
3	Film		

The observed organs in a fish were divided into two parts: fish digestion and fish body. Microplastics within the fish body differed in size from those found in fish digestive samples. The variation in shapes and sizes of microplastics can vary, depending on the degradation processes and interaction with organisms. The shapes of microplastics in sediment are more diverse due to physical and chemical transformations, whereas in the fish body, they are influenced by the way fish consume them and interactions with the digestive system. This variation also includes the chemical composition and distribution of microplastics. The results of plastic fragmentation generally have sizes and diameters of less than 5 mm, referred to as microplastics. Further information on the number of microplastics by shape found in fish samples can be seen in **Figure 4**.

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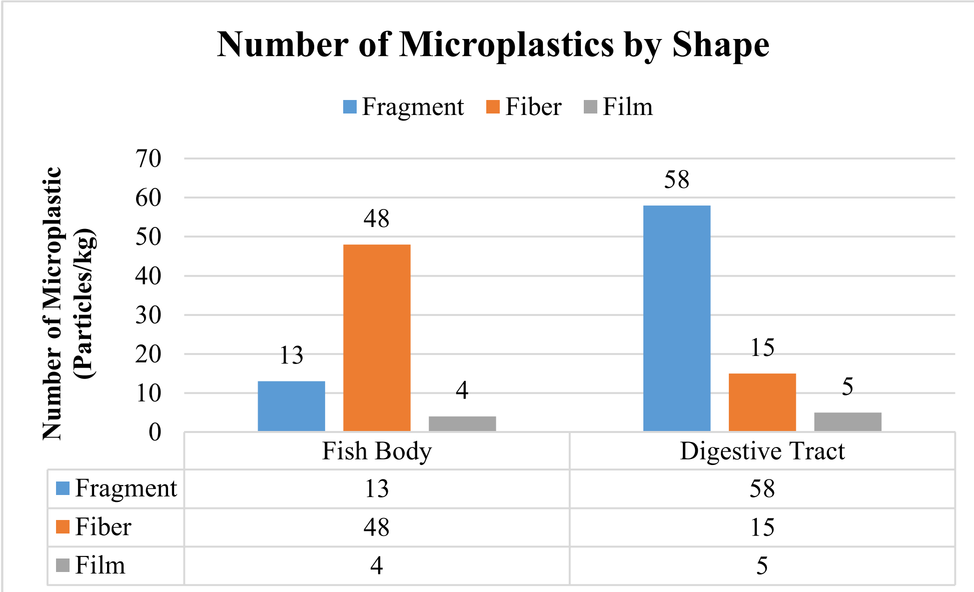

Figure 4. Number of microplastics by shape in fish samples

Microplastics were more commonly found in the digestive tracts of fish than in their bodies. This is because fish typically ingest microplastics along with their food in aquatic environments. Over time, microplastics can accumulate in the digestive tracts of fish, including in the stomach and intestines. The most common form of microplastics found were fragments, followed by fibers and films. Microplastic films are rarely digested by fish due to their relatively lower size and density compared to fibers and fragments. This results in a lower likelihood of these particles being swallowed and entering the digestive tracts of fish, considering the habitat and dietary patterns of these species. The presence of microplastics in fish is influenced by various factors, including size, density, the source of the microplastics, habitat, and dietary patterns (Cai et al., 2020; Amelinda et al., 2020; Tobing et al., 2020; Widiarnako et al., 2018).

d. Microplastic Colors in Fish

The study on fish samples found microplastics of various colors and varying quantities, as shown in Figures 5 and 6.

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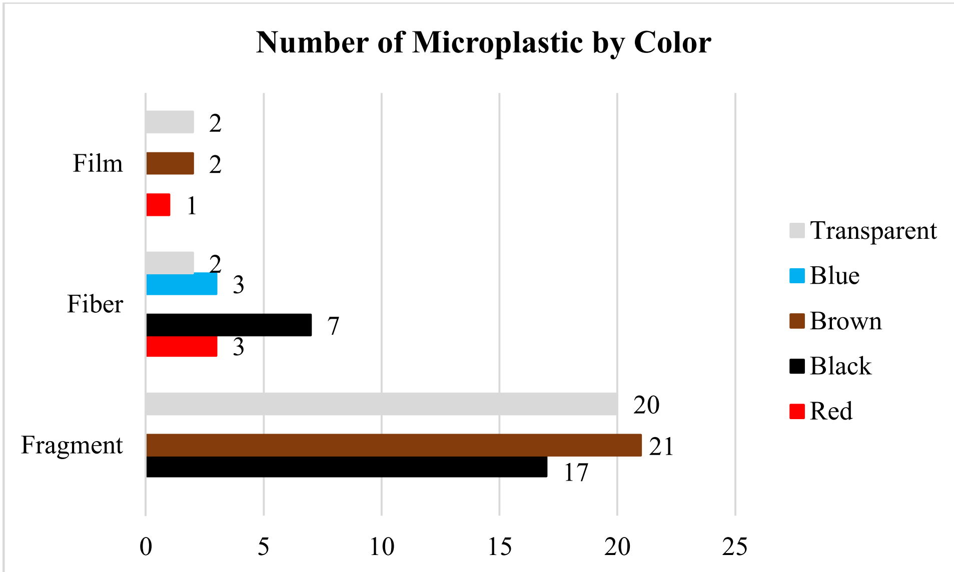

Figure 5. Number of microplastics by color in fish digestion tract

The colors of microplastics in fish digestive tract samples vary, with brown being the most dominant in fragment forms, followed by transparent and black, while red and blue colors were not found in microplastic fragments. The predominance of brown in the microplastics within fish digestive samples may be due to the degradation processes influenced by exposure to sunlight and oxygen in the aquatic environment (Sutrisno et al., 2018). The rare presence of blue is caused by the scarcity of blue-colored plastic types or color changes due to sunlight exposure (Febriani, 2020).

In fiber forms, the dominance of black indicates the presence of contaminants adhering to microplastics, caused by the ability of dark-colored microplastics to absorb other pollutant particles, which then affects the texture of the microplastics (Hiwari, 2019). The absence of brown-colored microplastics in certain forms is due to the difficulty in identification and the possible blending of brown with the tissues or stomach contents of fish, making it less visible during observation (Sutrisno et al., 2018). In film forms, the presence of brown is limited, while blue and black colors are not found, due to difficulties in detecting blue and black microplastics in fish digestive tract samples that can camouflage with the natural colors of marine organisms (Li et al., 2020). A more detailed description of the differences in color and the varying quantities in fish body samples can be seen in **Figure 6**.

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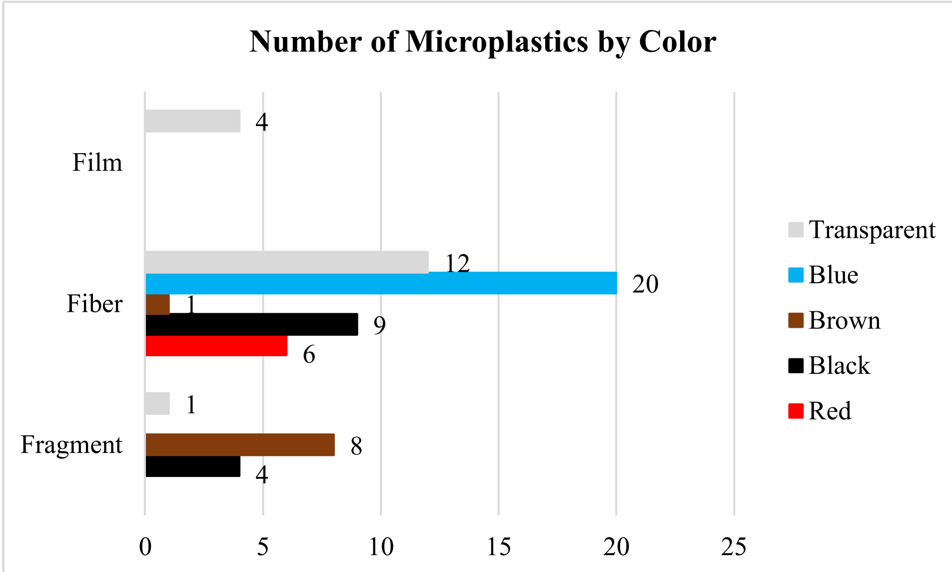

Figure 6. Number of microplastics by color in fish bodies

The colors of microplastics in fish body samples varied, with blue being the most dominant in fiber form, followed by transparent and black, while red, brown, and blue colors were not found in microplastic fragments. The predominance of blue-colored microplastics in these samples is due to the high number of blue microplastics in the waters where the fish were sampled, resulting from fishing activities. The fragmentation of fishing nets originally blue in color may lead to a higher likelihood of blue microplastics being consumed by fish (Akhbarizadeh, 2018). The transparent color in microplastics, particularly in fiber form, indicates that these microplastics have undergone extensive degradation due to climatic influences and sunlight exposure (Ratnasari, 2017).

The source of red-colored microplastics comes from the production of red plastics, which retain their color even after breaking down into microplastics. Meanwhile, the brown color in microplastics is caused by prolonged exposure to sunlight, resulting in the oxidation of the polymers. The absence of red and blue microplastics was suspected to be due to the low prevalence of red and blue plastic types polluting the aquatic environment, or they may have undergone discoloring or a reduction in color intensity, becoming transparent. Microplastics found in film form are only transparent, while red, blue, brown, and black colors are not found (Ratnasari, 2017 and Kapo, 2020).

3. FT-IR Test Results on Fish Samples

The FT-IR test results produced several peaks or absorption bands, as shown in Figure 7.

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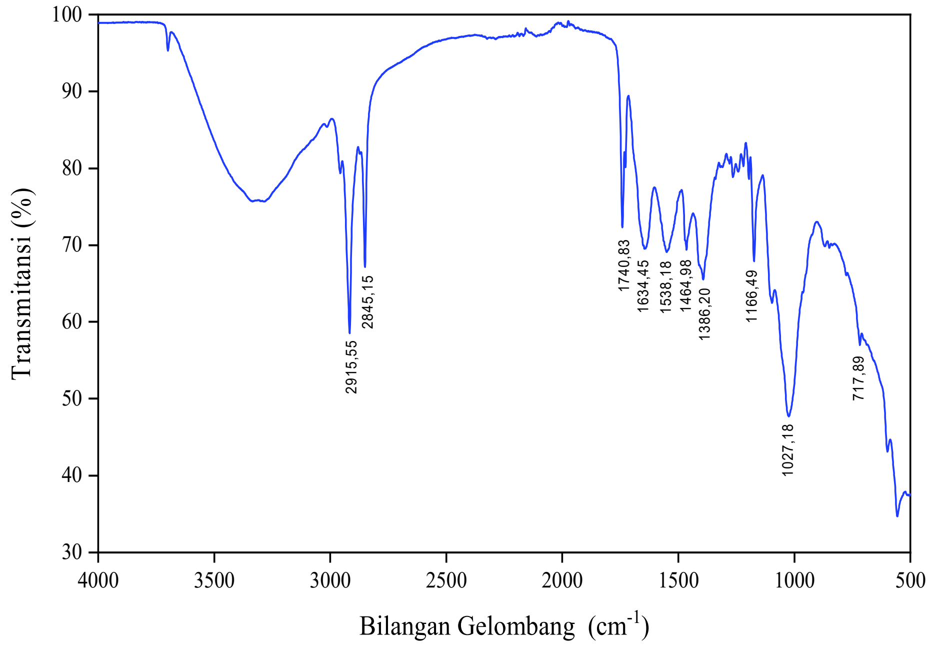

Figure 7. FT-IR results on fish samples

The FT-IR results on fish samples revealed that the most commonly found polymers are High-Density Polyethylene (HDPE) and Nylon, with both having two absorption bands. HDPE was detected at absorption bands 2915.55 cm^{-1} and 2845.15 cm^{-1}. HDPE is known as a strong, hard plastic that is resistant to low temperatures (Seprandita, 2022). Meanwhile, Nylon was detected at absorption bands 1634.45 cm^{-1} and 1538.48 cm^{-1}, and is suspected to be the microplastic fiber form widely used in fishing gear (Nuzula, 2022). Additionally, other types of polymers were also detected in the fish samples, such as Ethylene Vinyl Acetate (EVA), Poly (methyl methacrylate) (PMMA), Polypropylene (PP), Polystyrene (PS), and Low-Density Polyethylene (LDPE). EVA was detected at the absorption band 1740.83 cm^{-1}, while PMMA was at 1386.20 cm^{-1}. PP was detected at 1166.49 cm^{-1}, PS at 1027.18 cm^{-1}, and LDPE at 717.89 cm^{-1}. These types of plastics are generally used in various everyday products such as bottles, packaging, household utensils, and others (Alsabri et al., 2022; Nazarni, 2020; Cole, 2011).

Conclusion

The abundance of microplastics tends to be higher in sediment than in fish samples. The total abundance of microplastics in the sediment reached 1630 particles/kg, while in fish samples, the abundance of microplastics in the digestive tract reached 975 particles/kg, and in the fish body reached 135 particles/kg. The forms of microplastics found in the sediment and in the Kuwe Fish at Gampong Jawa Coast, Banda Aceh, include fragments, fibers, and films. In the sediment, the dominant color was brown, followed by black, transparent, and blue. In fish samples, the forms of microplastics found also include fragments, fibers, and films, with the dominant colors being brown, followed by transparent, black, blue, and red. The FT-

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IR analysis of microplastics in fish samples indicated the presence of various types of microplastic polymers, including Polypropylene (PP), Polystyrene (PS), Poly (Methyl Methacrylate), Ethylene Vinyl Acetate (EVA), Nylon, High-Density Polyethylene (HDPE), and Low-Density Polyethylene (LDPE).

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