Characteristics of microplastics in the digestive system of spotted scat (*Scatophagus argus*) from Pangempang, Muara Badak, Kutai Kartanegara, East Kalimantan

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ABSTRACT

Indonesia produces approximately 5.4 million tons of marine debris, making it the second-largest contributor of ocean waste in the world. This fact illustrates that all plastic waste discarded on land eventually ends up in the ocean. This study aims to understand the characteristics of microplastics in spotted scat (Scatophagus argus) and to determine whether there is a relationship between the length of the fish and the abundance of microplastics. The procedure involved several stages, including literature review, field surveys, sample collection, dissection of the fish's digestive tract, and identification of microplastics using a Relife RL-M3T microscope at 10–20X magnification. Microplastic particles were separated using 22% KOH and 20% H_2O_2 solutions. The results showed that, from 10 fish samples analyzed, a total of 182 microplastic particles were found. The most dominant type was fiber, followed by film and fragment, with an average abundance of 18.2 particles per individual. This research is expected to serve as a reference for the sustainable management of aquatic environments and to provide essential information for plastic waste control policies.

INTRODUCTION

Indonesia generates approximately 5.4 million tons of marine waste annually, making it the second-largest contributor of marine debris worldwide (Murlianti, 2022). In addition, the country remains one of the largest importers of plastic waste (Rohman et al., 2022). The degradation of plastic materials through photodegradation, oxidation, and mechanical abrasion produces smaller particles known as microplastics (Thompson et al., 2009). These particles persist in aquatic environments, accumulate along coastlines, and interact with marine organisms, raising concerns about their long-term ecological impacts.

Microplastics are generally categorized into fragments, films, fibers, and beads (Nur & Obbard, 2014). Fibers are commonly associated with domestic activities and fishing operations, while films originate from packaging materials and are characterized by low density and fragile structure (Purba, 2018). Fragments, on the other hand, are thicker and irregular, resulting from the breakdown of larger plastics (Purba, 2018). Meanwhile, beads represent primary microplastics manufactured as raw materials for plastic products (Kingfisher, 2011). The diversity of these forms reflects the multiple pathways through which plastics enter and persist in marine ecosystems.

Muara Badak, a coastal sub-district in Kutai Kartanegara Regency, East Kalimantan, is one of the regions heavily impacted by plastic waste (Dewi et al., 2015). The accumulation of microplastics in this area poses significant ecological risks, including internal organ damage, digestive tract blockages, and potential carcinogenic or endocrine-disrupting effects in marine organisms (Oehlmann et al., 2009). These impacts highlight microplastics as a serious threat to biodiversity and ecosystem health, particularly in tropical coastal ecosystems where fisheries and marine resources play a vital role in local livelihoods.

Despite increasing global concern, the occurrence and characteristics of microplastics in spotted scat (*Scatophagus argus*), a species commonly found in East Kalimantan waters, remain poorly documented. As an omnivorous fish inhabiting estuarine and coastal environments, S. argus is highly exposed to pollutants, making it a suitable bioindicator for microplastic contamination. Therefore, this study aims to identify and characterize the types of microplastics present in the digestive system of spotted scat from Pangempang, Muara Badak, providing insights into the extent of plastic pollution in East Kalimantan waters and its potential implications for fish health, ecosystem stability, and food web dynamics.

METHODOLOGY

The research was conducted over a period of approximately three months. The sampling location was situated in the Pangempang area of Muara Badak, Kutai Kartanegara, East Kalimantan. The examination of fish samples and related parameters was carried out at the Water Quality Laboratory, Faculty of Fisheries and Marine Sciences, Mulawarman University. The research location is illustrated as follows:

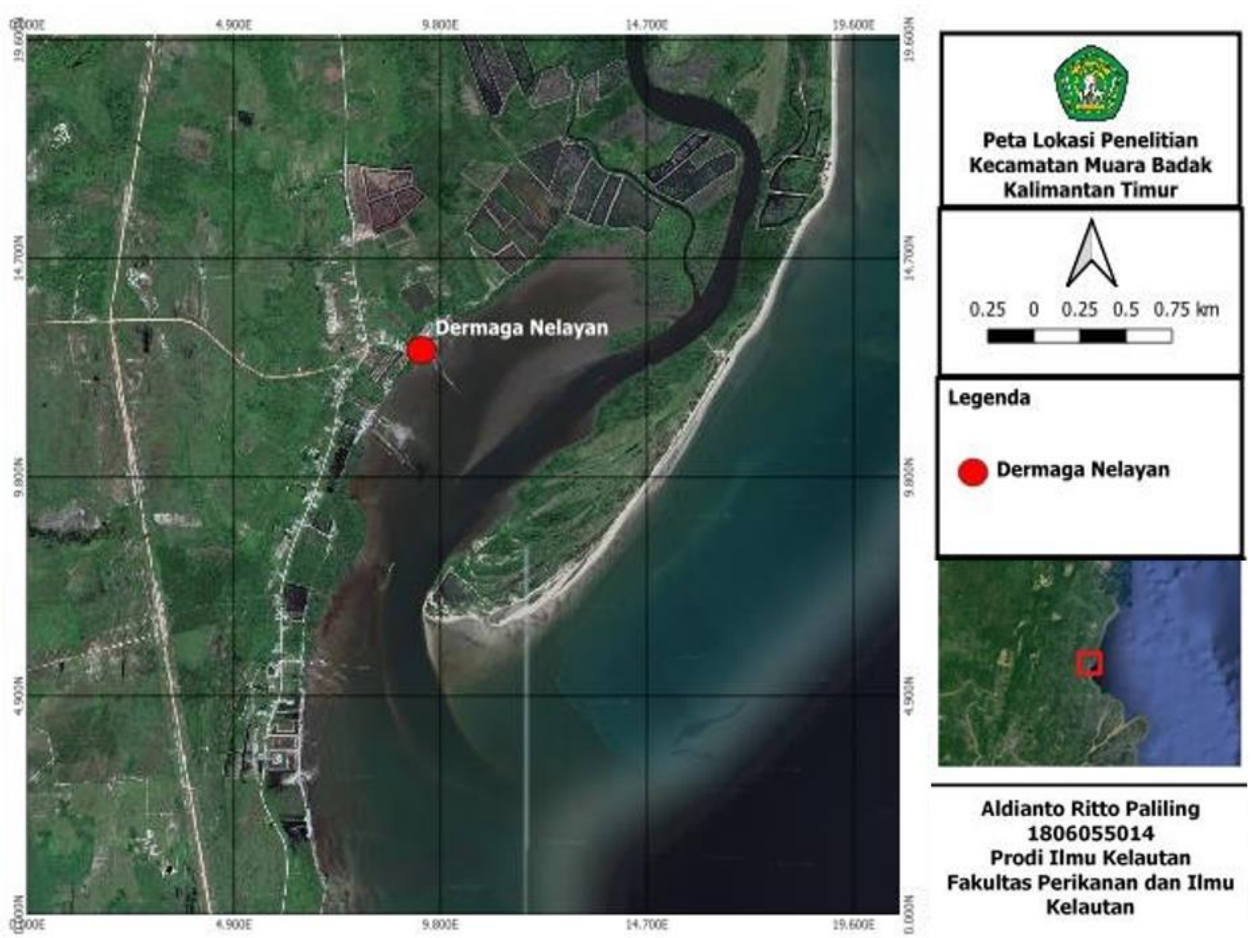

Figure 1. Study location map

Research Procedure

Field Observation

The determination of research stations was carried out using the purposive sampling method, based on specific considerations. The stations were selected according to the differing characteristics of each location, with the research station situated at the fish landing dock in Pangempang, Muara Badak, East Kalimantan.

Sampling method

Fish samples were collected by capturing fish at the fish landing dock in Muara Badak. This study used primary data obtained through direct sampling in the field. A total of 10 spotted scat (Scatophagus argus) specimens were randomly sampled.

Extraction of samples from the fish digestive tract

The methodology used in this study was based on the approach established by Rochman (2015). To prevent environmental contamination, all equipment was carefully cleaned using distilled water to ensure no contamination occurred. Additionally, the fish samples were recorded and measured for length and weight; the fish were dissected, and their digestive systems were extracted and placed in a measuring beaker. The digestive tract was then immersed in a 22% KOH solution, fully submerged at about three times the volume of the digestive tract, to digest the fish tissue (biological material). The measuring beaker containing the digestive system and 22% KOH solution was wrapped in aluminum foil and then digested for approximately 15 to 30 minutes at room temperature. If, after the initial digestion with 22% KOH, there were still undissolved residues from the fish digestive tract, further processing was required. The second step involved adding 5 ml of 20% H_2O_2 solution; the digestive system treated with 20% H_2O_2 was then digested again for about 10 minutes at room temperature. After the fish digestive tract was completely dissolved, the digested material was filtered using a 200 µm mesh sieve to facilitate sample separation. The filtered sample was rinsed with distilled water during transfer to a beaker, followed by filtration through Whatman filter paper. The Whatman filter paper containing the sample was placed in a cupcake liner wrapped with aluminum foil, then covered with additional aluminum foil, and dried in an oven at approximately 60ºC for 60 minutes to assist the identification process.

Identification of microplastic types

The identification process was carried out using a Relife RL-M3T microscope at 10–20X magnification. Samples on the partially dried Whatman filter paper were then subjected to the identification stage; the cupcake liner containing the sample was placed on the microscope stage, followed by adjusting the macrometer or micrometer to focus on the object. A USB cable connected the microscope to a laptop, facilitating observation and documentation of microplastic particles. Once microplastic particles were identified, they were documented, and the categories of microplastics found were recorded. Subsequently, the abundance of microplastics was statistically analyzed using Microsoft Excel.

Data Analysis

The quantity of microplastics in this study was determined according to Boerger et al. (2010) and is illustrated as follows:

$$Abundance\ (particles/ind) = \frac{Number\ of\ microplastic\ particles}{Number\ of\ fish}$$

The correlation between fish size (length) and the prevalence of microplastics in their digestive tracts was examined using simple linear regression, as shown below.

$$Y = a + bX$$

Simple linear regression is a mathematical model that represents the relationship between variables (X) and (Y), often depicted as a straight line (Yuliara, 2016). This test is used to determine whether fish length affects the concentration of microplastics in the digestive system of spotted scat

RESULT AND DISCUSSION

Description of Spotted Scat (*Scatophagus argus*)

The spotted scat (*Scatophagus argus*) resembles the discus fish, making it suitable as an ornamental fish. Adult spotted scats have black spots on their bodies, which tend to diminish or become less noticeable over time (Kottelat et al., 2001). The spotted scat has a flat, rectangular body similar to that of a pomfret, often measuring around 16 cm in length and reaching a maximum length of 25 cm. Upon maturity, the reproductive organs of the spotted scat can reach up to 25 centimeters (Kottelat et al., 2001). Due to its similarity to the discus fish, the spotted scat is frequently kept as a decorative ornamental fish. Purwanto et al. (2019) stated that the main components of this ornamental fish's diet include shrimp parts, benthic plants, moss, and baby cuttlefish. The spotted scat has canine-like teeth and usually forages near the bottom of the water (Purwanto et al., 2019). It rarely appears near the water surface or roams the bottom layers; this fish actively feeds during the day and primarily rests at night (Purwanto et al., 2019).

Figure 2. Spotted scat (*Scatophagus argus*)

Identification of Microplastic Types and Characteristics

The characteristics of microplastics found in this study are presented in Figure 4. Three forms of microplastics were identified in the fish samples: fibers, fragments, and films. Overall, fibers were the most abundant with 104 particles, followed by fragments with 12 particles, and films with 66 particles. The high number of fibers found in this study is similar to the findings of Rochman et al. (2015), where fiber-type microplastics accounted for up to eighty percent. This is due to the low density of fibers, which allows them to float on the water surface, causing fish that frequently take in oxygen at the surface to unintentionally ingest them, resulting in fiber microplastics dominating in the fish's body (Razeghi et al., 2021). Fibers and films are generally the most commonly found types of microplastics in many studies of microplastics in marine waters globally (Matjašič et al., 2021)

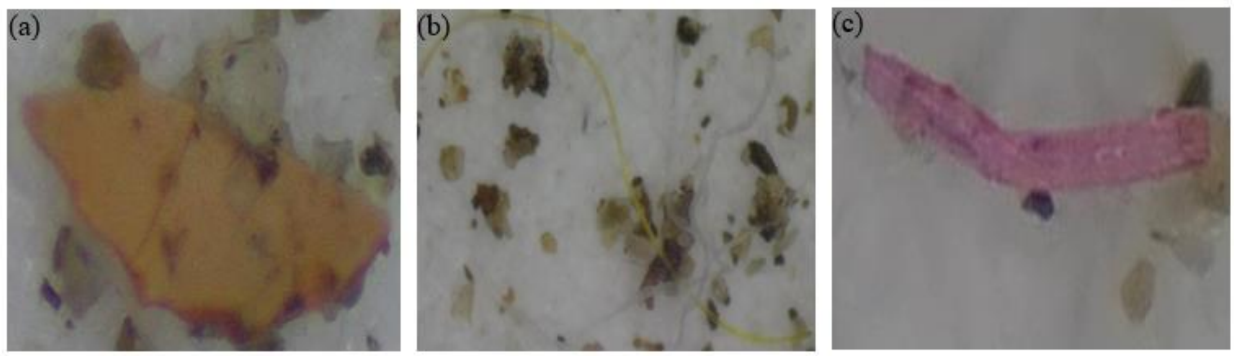

Figure 3. Microplastic images of types (a) fragmen, (b) fiber, (c) film

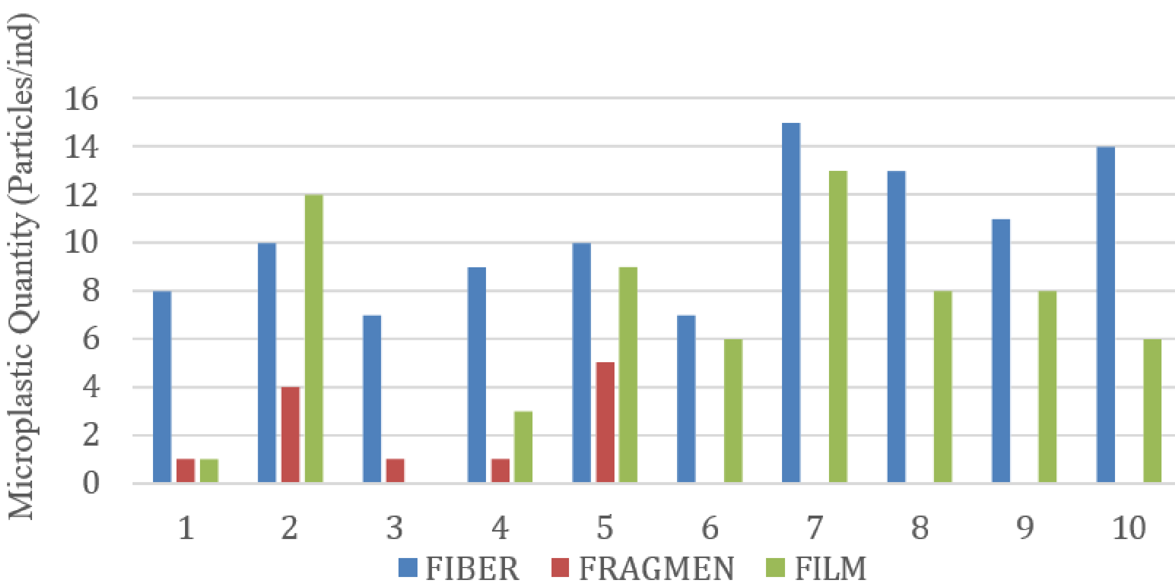

Figure 4. Characteristics of microplastics in spotted scat

Presentation and Abundance of Microplastic Types

Microplastics identified in the digestive system of spotted scat include fibers, fragments, and films. The prevalence of these microplastic forms in the digestive tracts of spotted scat shows considerable variability in quantity. Table 1 below presents a detailed count of the various microplastic types.

Table 1. Presentation of microplastics in spotted scat

Type	Particle	Percentage (%)	Abundance (particles/ind)
Fiber	104	57	10,4
Fragmen	12	7	1,2
Film	66	36	6,6
Total	182	100	18,2

This study revealed the composition of microplastics as 57% fibers, 7% fragments, and 36% films. Fibers mostly originate from polyamide and polyethylene materials related to fishing operations, such as fishing lines, nets, and trawls (Ayuningtyas et al., 2019). Findings from the study by Yona et al. (2020) showed that fish living in coastal waters near human activities are vulnerable to fiber exposure.

Analysis of the Relationship Between Fish Length and Microplastic Quantity

The results of the study showed a correlation between fish length and the number of microplastic particles present in the fish's digestive tract (Table 2).

Table 2. Data on microplastic quantity and spotted scat length

Fish Samples	Microplastic Quantity	Fish Length (cm)
1	10	17,7
2	26	16,3
3	8	16,9
4	13	17,3
5	24	20,1
6	13	18,3
7	28	16,6
8	21	16,2
9	19	17,8
10	20	25,2

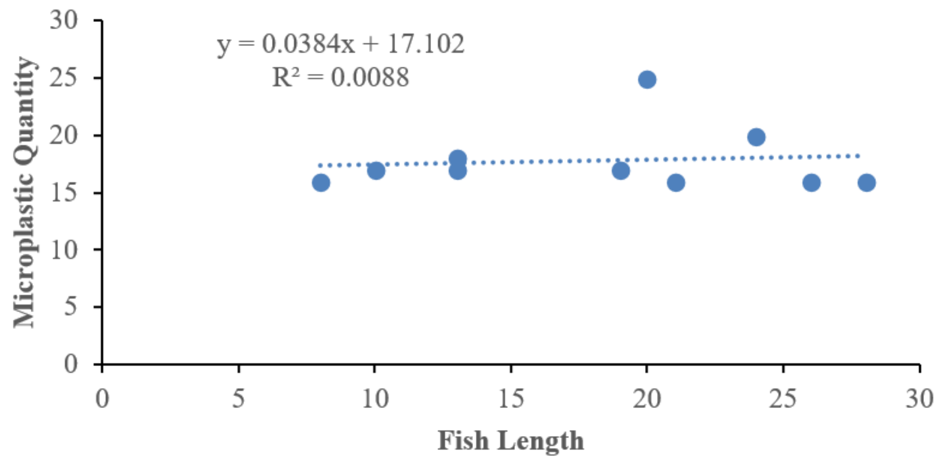

Figure 5. Results of the simple linear regression test on the relationship between spotted scat length and microplastic quantity.

The findings from the simple linear regression analysis regarding the correlation between the length of the spotted scat and the number of microplastics present in its digestive tract are illustrated in Figure 5.

The determination coefficient value was 0.0088, indicating that the effect of spotted scat length on microplastic levels is very small. Additionally, the correlation coefficient of 0.0937 shows a weak relationship between the length of the spotted scat and the amount of microplastics found. The study by Bessa et al. (2018) found that the correlation between microplastic concentration and fish length was negative or low, which may be due to the varying sizes of fish samples used. Nevertheless, the validity of this finding remains unproven; the extent to which microplastics enter the fish's digestive tract is largely influenced by the environment and the availability of food from marine biota after examination (Vries et al., 2020)

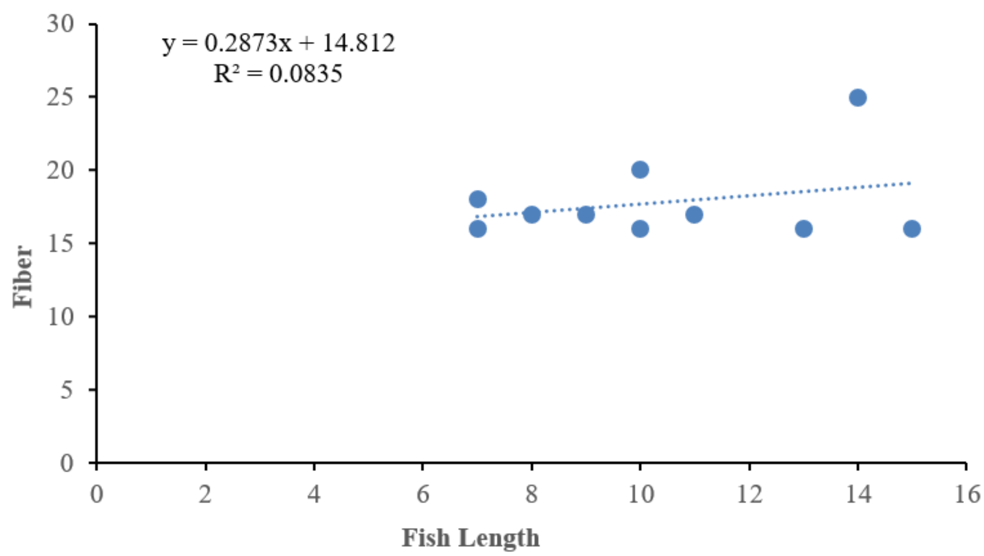

Figure 6. Results of the Simple Linear Regression Test on the Relationship Between Spotted Scat Length and Fiber Microplastics

The determination coefficient value was 0.0835, indicating that the effect of spotted scat length on the quantity of fiber-type microplastics is very low. The correlation coefficient of 0.2888 indicates a weak relationship between the length of the spotted scat and fiber microplastics. The analysis conducted in this study exclusively used fish length data, as fish length consistently increases with age. This approach provides more accurate data compared to using fish weight, which can vary due to factors such as habitat, health, and feeding behavior (Sem et al., 2023)

CONCLUSION

Microplastics found in the digestive tract of Spotted Scat (Scatophagus argus) are of the fiber, fragment, and film types. The abundance of fiber type microplastics was 10.04 particles per individual (57%), fragments 1.2 particles per individual (7%), and films 6.6 particles per individual (36%), with a total abundance of the three microplastic types reaching 18.2 particles per individual.

The determination coefficient value of 0.0835 indicates a low influence of Spotted Scat length on the amount of microplastics, and the correlation coefficient of 0.2888 shows a weak relationship between Spotted Scat length and microplastic quantity.

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