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Microplastic Content in Fish and Sea Water at Air Tawar Coast, Padang City, Indonesia

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Abstract

Every year, millions of tons of plastic contaminate marine ecosystems, disrupting the natural balance and endangering marine life. Marine debris, especially plastic, is exposed to sunlight and repeated physical activities in the ocean, eventually breaking down into microscopic particles known as microplastics. This research aims to identify the presence of microplastics in fish and seawater at Air Tawar Coast, Padang City, Indonesia, based on their shapes, colors, and sizes. Seawater samples were collected at 3 stations using purposive random sampling along the direction of net trawling. Water samples were collected using a plankton net and filtered horizontally at the sea surface. Fish samples were obtained from the catches of fishermen, using trawl net (maelo pukek). The fish sampled were Selar and Kembung fish. Microplastics found in seawater and fish exhibited various shapes, including fibers, films, fragments, and pellets, with pellets and granules being the most dominant shapes. The colors of microplastics found in this study were black, brown, red, orange, blue, yellow, green, and purple, with dark colors (black and brown) being the most dominant. The abundance of microplastics at station 1 was 140.12 particles/m^3, at station 2 was 151.27 particles/m^3, and at station 3 was 129.61 particles/m^3. The number of microplastic particles found in Kembung was higher than in Selar. On average, Selar fish contained 228 particles/individual, while Kembung fish contained an average of 267.5 particles/individual. The smallest particle size was found in pellet form, with a size of 8.12 µm, while the largest particle size was found in film form, measuring 174.56 µm.

1. Introduction

Marine pollution caused by plastic waste is a serious and increasingly urgent global issue. Every year, millions of tons of plastic contaminate marine ecosystems, disrupting the natural balance and endangering marine life (Nurul *et al.*, 2022). This phenomenon is inevitable as the population grows and human activities increase waste production, especially plastic, every year. According to Subekti (2010), marine pollution begins with littering, which directly affects the health and cleanliness of the surrounding environment. When it rains, the waste is carried into water bodies, increasing the river's water discharge. This causes the trash to be swept by the current toward the river mouth and eventually carried to the sea.

Microplastics are tiny plastic particles, typically measuring <5 mm in size or even as small as dust particles (Sutan Haji *et al.*, 2021). The small-sized microplastics that tend to float in these waters are likely to be consumed by marine organisms such as fish, shrimp, squid, and others. Organisms contaminated with microplastics experience damage to their digestive tracts (stomach, intestines, and gills) and an increased potential for mortality. Accumulation of microplastics in the bodies of these organisms can lead to physical and chemical damage such as internal organ damage and digestive tract blockage.

The city of Padang has a coastline stretching approximately 73.65 km in length as of 2021, encompassing an ocean area of approximately 72,000 hectares with 19 small islands (Driptufany *et al.*, 2022). The presence of coastal areas in Padang has led to a significant portion of the city's population engaging in fishing as their profession. Consequently, there is a high level of interest among the residents of Padang in consuming fish, as they can easily access fresh catches. The population growth in the city of Padang is increasing annually, accompanied by various activities conducted by its residents, such as industrial waste disposal, agriculture, and indiscriminate household activities. The consequence of this trend is the escalating water pollution in the vicinity of Padang.

This study focuses on the characteristics and abundance of microplastics at Air Tawar coast, Padang City. The main aspects examined include the shapes of microplastics found in fish and seawater samples, the colors of these microplastics, and their overall abundance in the area. The findings from this study are expected to provide valuable information about the condition of microplastics at the waters and serve as supporting data for related research in the future.

2. Material and methods

2.1. Materials

The material taken and analyzed in this study comprises fish and seawater collected from the area of Air Tawar Coast, Padang, West Sumatra.

2.2. Methods

2.2.1. The collection of seawater samples

The determination of sampling points was conducted at 3 three different locations/stations using the purposive random sampling method along the direction of the trawl net retrieval. Seawater samples were collected using a plankton net. Seawater samples were collected horizontally by filtering water using a plankton net with a diameter of 20 cm and a mesh size of 25 µm. The net was towed through the water surface by a moving vessel at a speed of 2-3 knots along a distance of 100 m. Samples from the surface of the seawater at each station were collected in an amount of 250 mL using a plankton net with a mesh size of 25 µm. After filtering all the water, the plankton net was rinsed with distilled water to ensure that all microplastic samples entered the funnel and were not left in the net (Hanif *et al.*, 2021). The filtered results were transferred into sample bottles and placed in a coolbox to maintain sample integrity and prevent damage.

2.2.2. The collection of fish samples

The fish samples were obtained from the catches of fishermen using the traditional method called "maelo pukek" (net hauling/trawl net). Maelo pukek is a fishing activity carried out by coastal fishermen. Fishermen cast nets at a distance of approximately 250-300 m from the shoreline, and then the nets are collectively pulled toward the shore by a group of 10-15 people. From the catch, two randomly selected fish species, Selar and Kembung, were chosen, and three fish were sampled from each species with approximately the same weight of 125g. After that, the samples were collected, labeled, and stored in a coolbox during transport to the laboratory.

2.2.3. The microplastic extraction from seawater samples

The seawater samples obtained from each station were poured into a 250 mL glass beaker. Subsequently, 10 mL of 30% H_2O_2 was added, and the mixture was stirred for 5 mins using a hot plate and magnetic stirrer at 70°C with a speed of 180 rpm. Then, a solution of 10 mL $FeSO_4.7H_2O$ (0.05M) was added, and the mixture was stirred for another 30 mins. Next, 10 mL of 30% NaCl solution was added, and the mixture was stirred for an additional 30 mins. The sample solution was filtered using a vacuum pump and dried on Whatman filter paper overnight. The dried samples were then analyzed for shape and quantity using a microscope (Suryati *et al.*, 2020).

2.2.4. The microplastic extraction from fish samples

The fish were dissected, and their digestive tracts (intestines and stomach) were extracted. Subsequently, the gills and digestive tracts were submerged in a 10% KOH solution until completely covered (approximately 3 times the volume of the tissue) to digest the fish's digestive system (Yudhantari *et al*., 2019). The container was then covered with aluminum foil and incubated at 60°C for 24 hours. Next, the samples were digested using a 30% H_2O_2 solution, approximately 5 mL, for 24 hours at room temperature. The digestion process was considered complete when the samples became clear. Afterward, the water from the fish samples was collected and filtered using Whatman No. 42 filter paper. The filter paper containing the samples was then placed in a petri dish for identification under a microscope (Yona *et al.*, 2020).

2.2.5. The abundance of microplastics

The abundance of microplastics can be calculated by determining the number of microplastic particles found in the water sample, considering the total volume of water filtered. According to Immanuel et al. (2022), the abundance of microplastics in seawater can be calculated using the formula:

$$Microplastic\ Density = \frac{Number\ of\ Microplastics\ (particles)}{Filtered\ Water\ Volume\ (m^3)}$$

Filtered water volume (m^3) =
$\pi r^2 \times$ The swept area of the plankton net (m)

Given:
The swept area of the plankton net = 100 m
r = 10 cm = 0.1 m

Therefore,
Filtered water volume (m^3) =
$\pi r^2 \times$ The swept area of the plankton net (m)
$= 3.14 \times 0.01\ m^2 \times 100\ m$
$= 3.14\ m^3$

3. Results

3.1. Visually identify microplastic particles

The results of visual observations under a microscope of microplastics can be distinguished based on their shape and color (Figure 1). There are 4 types of microplastics found, including fragments, pellets, films, and fibers. Each microplastic has its own distinct shape and characteristics. Fiber-type microplastics have elongated shapes like threads or fibers, typically originating from fishing nets and are commonly found in coastal areas due to the activities of coastal communities engaged in fishing. Film-type microplastics typically appear as thin sheets. Pellet-type microplastics are small, round, and usually black in color. Fragment-type microplastics have irregular shapes resembling shards of glass with sharp edges and a hard texture.

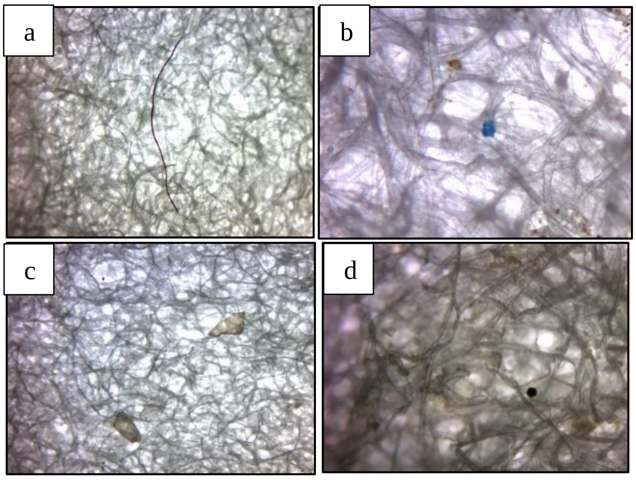

Figure 1. Identification of microplastics based on the shape of (a) fiber, (b) fragment, (c) film, (d) pellet

In Figure 2, various colors of microplastics found in the waters of Air Tawar Coast and in fish caught around the coastal waters are depicted. The colors found include black, brown, red, orange, blue, yellow, green, and purple.

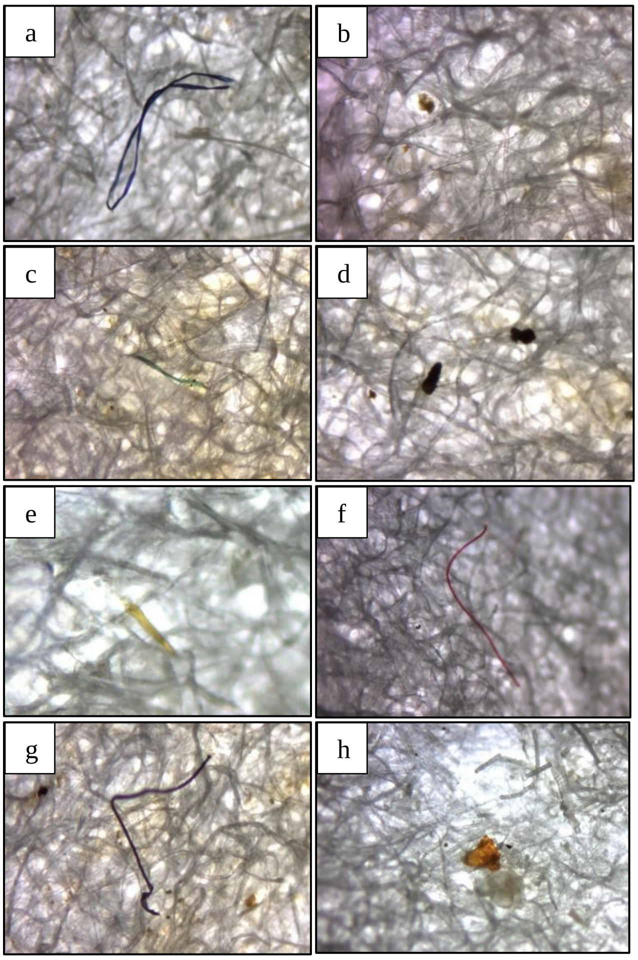

Figure 2. Microplastic Identification Based on Color: (a) Blue,(b) Brown,(c) Green,(d) Black,(e) Yellow,(f) Red,(g) Purple,(h) Orange

3.2. Number of microplastic particles

3.2.1 Percentage of the number of microplastic particles in sea water based on shape

In Figure 3, it is shown that pellet-shaped microplastic particles are more dominant compared to other microplastic shapes, accounting for 30% of the total amount, slightly higher than fragments, which make up about 28%. Ranking third, fibers contribute around 24% of the total. Meanwhile, the least found shape in the waters of Air Tawar Coast is film, comprising approximately 18% of the overall samples.

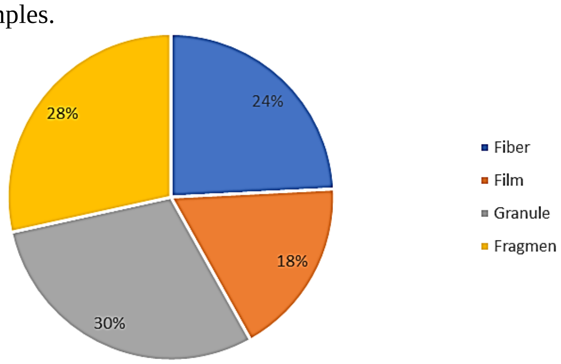

Figure 3. Percentage of microplastic particles in seawater from the three stations at Air Tawar Coast based on the shape

3.2.2 percentage of the number of microplastic particles in sea water based on color

Figure 4 shows that the most dominant color of microplastics is black, accounting for 33% of the total. This is followed closely by brown, which makes up 29%. Red comes next with 15%, orange at 13%, blue at 4.5%, yellow at 2%, and the least common colors are green and purple, at 0.7% and 0.6%, respectively.

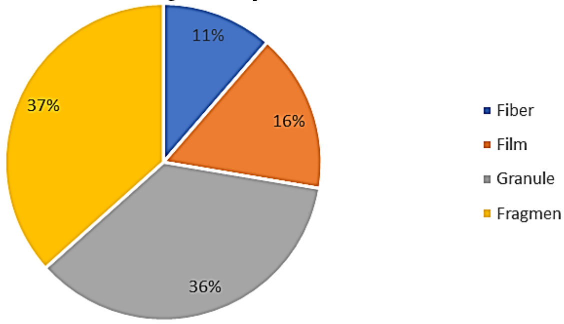

Figure 5. Percentage of Microplastic Particles in the Gills of Selar and Kembung Fish Species by Shape

3.2.3 Percentage of the number of microplastic particles in fish gills based on color

Figure 6, shows that the most dominant color of microplastics is black, accounting for 43% of the total. This is followed by brown at 34%, orange at 12%, red at 7%, yellow at 2%, blue at 2%, and the least found colors are green and purple, both at 0%.

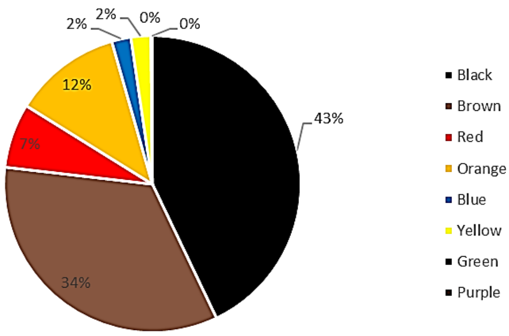

Figure 6. Percentage of Microplastic Particles in the Gills of Selar and Kembung Fish Species by Color

3.2.4 Percentage of the number of microplastic particles in fish digestion based on shape

In Figure 7, it is shown that fragment-shaped microplastic particles dominate other shapes, accounting for 37% of the total microplastics, followed by pellets at 33%. Ranking third, films make up about 18% of the total. Meanwhile, the least found shape in the digestive systems of Selar and Kembung fish is fiber, comprising about 13% of the overall samples.

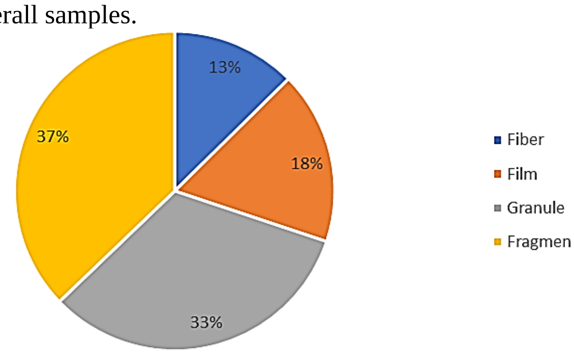

Figure 7. Percentage of microplastic particles in the digestive systems of Selar and Kembung fish species by shape

3.2.5 Percentage of the number of microplastic particles in fish digestion based on color

Figure 8, shows that the most dominant color of microplastics is brown, accounting for 39% of the total. This is followed closely by black at 38%. Orange makes up 12%, red 7%, yellow 2%, blue 1%, and the least common colors are green and purple, both at 0%.

3.3. Abundance of microplastics in sea water

The results of microplastic abundance shown in Figure 9 indicate that the highest abundance of microplastics is at station 2, with 151.27 particles/m^3. Station 1 has the second highest abundance at 140.13 particles/m^3, while station 3 has the lowest abundance, with 129.62 particles/m^3.

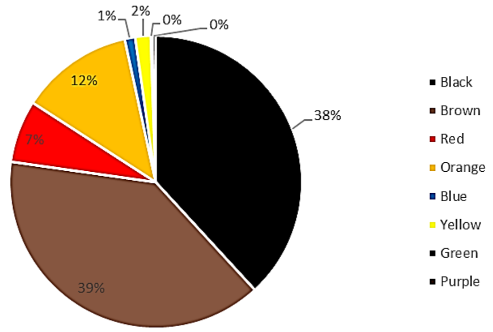

Figure 8. Percentage of microplastic particles in the digestive systems of Selar and Kembung fish species by color.

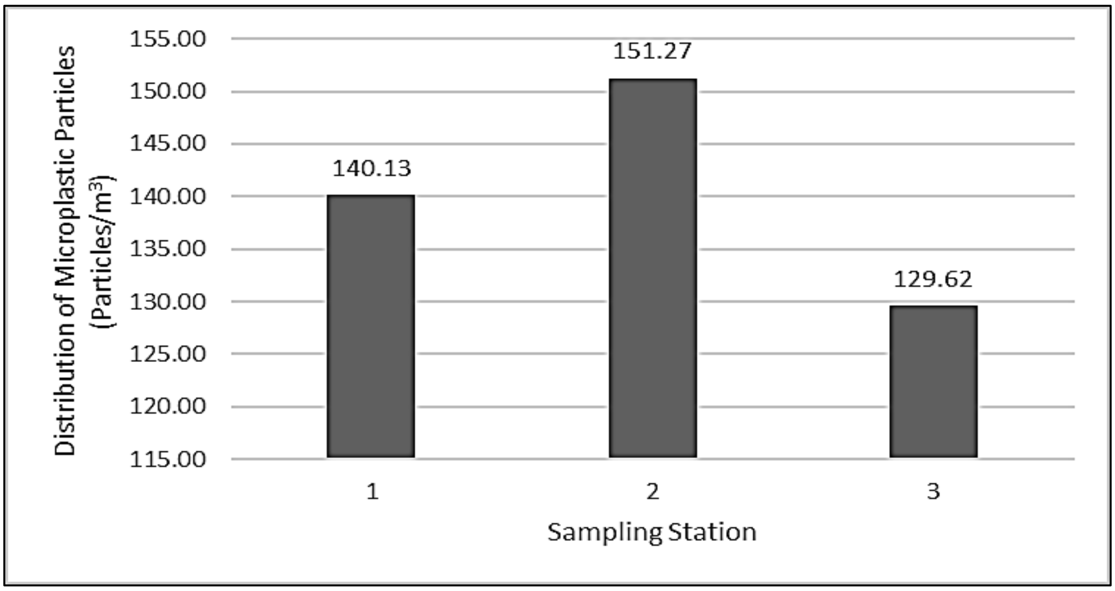

Figure 9. Distribution of microplastics in sea water

4. Discussion

4.1. The presence of microplastics in sea water

The high microplastic content in the waters of Air Tawar can be attributed to the sampling being carried out during the rainy season. This is supported by Mardiyana and Kristiningsih (2020), who state that microplastics tend to reach their peak abundance during the rainy season, when coastal areas receive water flow from rivers carrying plastic fragments through the coastal. The high accumulation of microplastics in these waters can also be attributed to the sampling locations being close to residential areas and fishing activities.

Pellet and fragment-shaped microplastics are the most frequently found types compared to fibers and films. Water samples were collected using a plankton net, which was dragged horizontally for 100 m at the surface of the seawater. Therefore, pellet-shaped microplastics dominate the waters of Air Tawar Coast because this type of microplastic has a low density, making it easily carried by currents and able to float on the water's surface (Seprandita *et al.*, 2022). The location of seawater sample collection near coastal residential areas allows for the frequent occurrence of fragment-type microplastics. This is due to the habit of residents disposing of waste into rivers, which then flows into the sea and breaks down into small pieces, forming fragments (Sandra and Radityaningrum, 2021).

The colors of microplastics found in the water include black, brown, red, orange, yellow, blue, green, and purple. Black-colored microplastics dominate the water because they are believed to originate from black plastic bags commonly used by people in their daily lives. It is estimated that these microplastics absorb a lot of contaminants (Ibrahim *et al.*, 2023). Meanwhile, brown-colored microplastics are generally particles that have been exposed to UV rays for a long time and may contain pollutants such as PCBs and PAHs.

4.2. The presence of microplastics in fish

The number of microplastics detected in the digestive systems and gills of Selar and Kembung fish differs. The total number of microplastic particles found in the gills of Kembung fish is higher than in Selar fish. This difference in microplastic quantity may be due to differences in their feeding patterns and food preferences. Kembung, which primarily feeds on plankton, tends to ingest microplastics carried by small microplankton in the water (Sandra and Radityaningrum, 2021), while Selar, which tends to consume larger and more diverse food items such as small fish and other marine organisms, may ingest fewer microplastics (Amin *et al.*, 2024).

The presence of microplastics in the gills of fish is caused by several factors, one of which is the respiratory process of the fish itself. The gills function as respiratory organs in fish, where water flows through them to extract the oxygen needed for respiration. This is supported by Su *et al.* (2019), who state that gills can become a site for the accumulation of microplastics because they serve as entry and exit points for water during the respiratory process.

The presence of microplastics in the digestive systems of marine organisms can be attributed to the contamination of the waters of Air Tawar Coast, as it is located near the river estuary. Additionally, this is suspected to occur because Selar and Kembung fish are categorized as carnivores, feeding on larvae, plankton, and small fish. These small fish are believed to have been contaminated with microplastics, thereby indirectly causing Selar and Mackerel fish to consume prey that is contaminated with microplastics. This statement is supported by Yona *et al.* (2020), who state that the ingestion of microplastics by aquatic organisms occurs because these small plastic particles can be swallowed when fish are feeding.

The most dominant forms of microplastics found in the gills and digestive systems of fish are fragments and pellets. Fragment-type microplastics have irregular structures with sharp edges, usually originating from strong plastic polymers such as pieces of drinking bottles, PVC pipes, and other food packaging materials (Ridlo et al., 2020). Pellet-type microplastics can originate from materials used in household activities, such as wastewater containing plastic pellets (Hiwari *et al.*, 2019).

The colors of microplastics found in the digestive organs and gills of Selar and Kembung fish exhibit similarities in color variation, including black, brown, red, orange, yellow, blue, green, and purple. However, in the gills, no green color was detected. The most dominant color in the gills is black, accounting for 43%, while in the digestive organs, the most dominant color is brown, comprising 39%.

4.3. Microplastic size

The sizes of microplastics found in the waters of Air Tawar Coast and marine organisms vary considerably. The smallest particle size was found in pellet form, measuring 8.12 µm, while the largest particle size was found in film form, measuring 174.56 µm. Differences in microplastic sizes can also be attributed to natural processes such as the physical and chemical degradation of large plastics into smaller fragments, which is one of the main factors affecting microplastic size. Microplastic size is also influenced by fragmentation processes occurring in the water. The longer the fragmentation process, the smaller the size of the microplastics (Avio *et al.*, 2015).

4.4. Abundance of microplastics in seawater

The abundance of microplastics in seawater ranges from 129.62 - 151.27 particles/m^3 with an average abundance of 140.34 particles/m^3, which can be categorized as high. In several studies, the abundance of microplastics found in various locations falls within lower ranges, such as in the study by Sainio *et al.* (2021) with an average microplastic abundance of 16.2 particles/m^3, and in the study by Salsabila *et al.* (2023) where the range of microplastic abundance is 21.53 – 46.97 particles/m^3. Therefore, the abundance of microplastics on the coast of Air Tawar coast can be considered relatively high in the context of microplastic research in aquatic environments. There are no global standards to determine whether microplastic abundance is high, moderate, or low. The abundance of microplastics depends greatly on pollutant sources and the characteristics of the research location (Fadhilah *et al.*, 2023). The abundance of microplastics at all three stations has a similar range of values. This is believed to be due to the distribution of microplastics influenced by current conditions and inputs from land (Ayuingtyas *et al.*, 2019).

5. Conclusions

The observations of microplastics revealed diverse forms, including fibers, films, fragments, and pellets. In seawater, the most dominant form of microplastics is pellets, while in the gills and digestive organs of fish, the most dominant form is fragments. The colors of microplastics found in this study include black, brown, red, orange, blue, yellow, green, and purple. In the waters of Air Tawar Coast and in fish, dark colors (black and brown) are more dominant compared to other colors. The abundance of microplastics was measured at 140.12 particles/m3 in station 1, 151.27 particles/m3 in station 2, and 129.61 particles/m3 in station 3. The abundance of microplastics in Air Tawar coastal can be categorized as quite high.

Ethics approval

No permits were required.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author contributions

YRA : sample image collection, water quality sampling collection. BY and MII : research ideas, supervising and writing

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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