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Characteristics and Abundance of Microplastics at Gastropods in Pasir Putih Beach, Banten

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Abstract

Poor waste management and the use of single-use plastics have led to microplastic contamination in the environment, particularly in water bodies that serve as final dumping grounds for plastic waste. There is a high likelihood that microplastics are mistaken as food by marine organisms, including gastropods that feed through deposit feeding. This study was conducted in January to June 2025 at the Pasir Putih Beach with the aim of identifying the families of gastropods present in the estuary, as well as the abundance and characteristics of microplastics found throughout the gastropod organs. The research method employed purposive sampling, and data analysis was conducted descriptively. The dominant microplastics in the Pasir Putih Beach Estuary are fiber-type microplastics, with black being the predominant color, resulting from degradation due to UV radiation and physical ocean conditions. Microplastics with a size of <1 mm were most commonly found in the Pasir Putih Beach Estuary. Station 6 exhibited the highest microplastic abundance, totaling 2,120 particles/gram.

Keywords: Microplastics, Gastropods, Marine debris

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Introduction

Environmental pollution, particularly in aquatic ecosystems, is increasingly becoming a global concern, primarily driven by ineffective waste management practices. According to the Indonesia National Waste Management Information System (Kementerian Lingkungan Hidup dan Kehutanan, 2024), more than 34 million tons of waste were generated in 2024, with 40% not managed properly. Of this total, approximately 10% of plastic waste ends up in marine environments, contributing to the growing presence of microplastics in coastal and estuarine areas (Cole et al., 2011). Microplastics are small plastic particles with a diameter of less than 5 mm and are categorized into two types: primary and secondary. Primary microplastics are intentionally manufactured at small sizes and found in products such as toothpaste, face scrubs, and industrial abrasives (Ivleva et al., 2017). Secondary microplastics, on the other hand, result from the degradation of larger plastic debris due to environmental factors such as wave action, ultraviolet (UV) radiation, and microbial activity (Ceccarini et al., 2018; Welden & Lusher, 2017). Due to their minute size, microplastics are easily ingested by marine organisms and can accumulate along the food chain. Among the most vulnerable organisms are benthic deposit-feeders such as gastropods, which can inadvertently consume microplastics present in sediments while feeding (Fitri & Patria, 2019). Gastropods inhabit a wide range of aquatic environments, from deep-sea and estuarine ecosystems to freshwater and terrestrial habitats. Their ecological importance as detritivores and sediment bioturbators, combined with their sensitivity to environmental changes, make them reliable bioindicators of microplastic pollution (Curren et al., 2024; Nurrohmah et al., 2025).

In Banten Province, particularly in Banten Bay, various anthropogenic activities including urban runoff, industrial discharge,

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aquaculture, and tourism contribute significantly to coastal pollution. Research by Wisha et al. (2022) revealed that during the northeast monsoon, plastic debris influx in Banten Bay can reach between 2.25 kg and 5.75 kg. Pasir Putih Beach, a part of this bay area, is characterized by muddy-sandy sediments and mangrove fringes that play a critical role in trapping suspended particles and pollutants. Pasir Putih Beach is not only ecologically sensitive but also socioeconomically important due to its proximity to residential areas and recreational zones. Despite this, there is a significant lack of scientific data on microplastic contamination in its coastal ecosystem, especially concerning invertebrates such as gastropods. The ecological role of gastropods in this area underscores the urgency of assessing microplastic pollution through biological indicators. Moreover, gastropods such as those from the families Ampullariidae and Potamididae, found in freshwater and mangrove ecosystems respectively, are frequently exposed to microplastic contamination. These organisms, due to their feeding behavior and sediment interaction, are potential accumulators of microplastics and related contaminants, including persistent organic pollutants (POPs) that adhere to plastic surfaces (Torres et al., 2021).

Additionally, the ingestion of microplastics by gastropods may have physiological consequences, including reduced feeding efficiency, impaired growth, and reproduction, as well as increased mortality. Such effects not only threaten gastropod populations but can also disrupt trophic interactions and ecological balance within the coastal ecosystem. Furthermore, since gastropods are part of the diet of commercially important fish and crustaceans, the presence of microplastics in these organisms poses potential risks to seafood safety and human health. To date, there is no documented research on microplastic contamination in gastropods from Pasir Putih Beach. This knowledge gap limits our understanding of how microplastics are distributed in this area and the extent of their biological uptake by benthic organisms. The primary objective of this study is to quantify the abundance and characterize the types of microplastics ingested by gastropods, evaluating their effectiveness as benthic bioindicators for microplastic pollution in the Pasir Putih Beach estuary, Banten. Although the baseline data generated provide valuable insights for coastal management and habitat conservation, the core focus of this work is centered on biological uptake and bioindication in benthic fauna.

Methods

This research was conducted from January to June 2025 at Pasir Putih beach (Figure 1). Sampling was carried out at six research stations: two stations located near residential areas (Station 1 and 2), two locations near fishponds (Station 3) and mangrove vegetation (Station 4), and two locations in the shoreline (Station 5 and 6). Sampling stations were selected using a purposive sampling method based on a spatial gradient of anthropogenic activities and ecological habitat types across the Pasir Putih Beach estuary (Figure 1). Stations 1 and 2 were established in slow-flowing, brackish waterways near dense residential areas to assess the impact of domestic runoff. Station 3 was situated adjacent to aquaculture fishponds, while Station 4 was located within mangrove vegetation to evaluate the potential filtering capacity of mangrove roots and muddy sediments. Stations 5 and 6 were positioned along the intertidal shoreline and estuarine mouth, areas directly exposed to hydrodynamic forces and marine debris accumulation from Banten Bay. This targeted spatial distribution ensures a comprehensive evaluation of microplastic uptake across distinct environmental stress levels and gastropod habitats. The tools used to collect gastropod samples in this study were glass jars, cool boxes, digital scales, plastic wrap, GPS devices, and gloves. Meanwhile, the equipment used to identify microplastics hotplate, pipet, Petri dish, and microscope. The materials used to collect gastropod samples in this study were distilled water, 70% alcohol, and Ziplock bags. Meanwhile, the materials used to identify microplastics are 30% $Fe_2(SO_4)_3$, and Whatman filter paper.

Gastropod collection was carried out using the purposive sampling method. Gastropod sampling was conducted along the Pasir Putih beach estuary, where research station locations had been determined. Each sample collected was stored in a labeled Ziplock bag containing 70% alcohol and then placed in a cool box. After obtaining gastropod samples, identification of documented gastropods was carried out based on findings and observations were made based on family and number at the UPI Laboratory, Serang Campus. In the identification process, the following books were used FAO: The living marine resources of the western central Pacific volume 1. Seaweeds, corals, bivalves, and gastropods (Carpenter & Niem, 1998) and *Moluska Jawa* (Marwoto et al., 2020). As a supporting medium for gastropod identification, this study also used the World Register of Marine Species (WoRMS) website at https://www.marinespecies.org/.

Microplastic identification in gastropods was conducted at the Ecoton Laboratory, Gresik. The identification was done in several stages, namely destruction, filtering, and identification. The identification process involved separating the body from the shell of the gastropods. After the shells and bodies were separated, the weight was measured using a digital scale. The next step was to add 5 ml of 30% $Fe_2(SO_4)_3$ solution to each gastropod sample and incubate it for 24 hours until the sample disintegrated. After that, the samples were placed on a hotplate for 30 minutes at a temperature of 70°C, then filtered using Whatman filter paper or cellulose nitrate filters, and the microplastic samples trapped on the filter paper are transferred to a sterile Petri dish using distilled water and identified under a microscope with 4x/0.10 magnification.

Microplastic identification includes the shape, color, and size of the particles found. The most common shapes of microplastics are pellets, fragments, fibers, films, foam, and granules (Löder *et al*., 2015). Microplastic size is categorized into five groups: <0.1 mm, 0.1–0.5 mm, 0.5–1.0 mm, 1.0–5.0 mm, and >5.0 mm (Digka et al., 2018). Meanwhile, microplastic colors are categorized into 8 colors based on the scheme by the European Marine Observation and Data Network (EMODnet), namely black/gray, white, blue/green, red/pink/orange/purple, yellow, brown, and transparent (Barnes et al., 2009). Gastropod diversity was analyzed descriptively based on graphical data from observations. Microplastics identified in gastropods were classified based on shape, color, and size, which were then processed using Microsoft Excel. Microplastic characteristics were presented in graphical form, while microplastic abundance was presented in tabular form and analyzed descriptively.

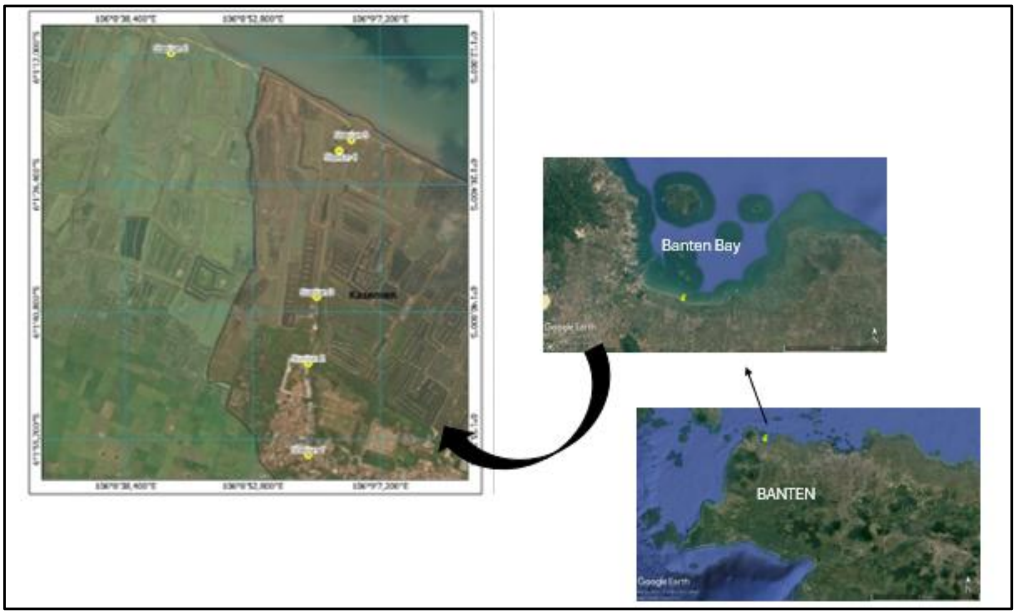

Figure 1. Sampling Location Site

Results and Discussion

Identification Results of Gastropods

There are three species of gastropods found in this study (Figure 2) at stations 1 and 2, *Pomacea canaliculata* was found in 7 individuals and *Pomacea diffusa* in 14 individuals, while at station 3, gastropods of the species *Pomacea canaliculata* were found in fewer numbers than at stations 1 and 2, amounting to 4 individuals, while gastropods of the species *Pomacea diffusa* had the same results as stations 1 and 2. The species of gastropods found at station 4 differed from the previous stations. At this station, 12 individuals of the species *Telescopium telescopium* were found, while at station 5, 14 individuals of the species *Telescopium telescopium* were found, and at the final station, there were fewer individuals, amounting to 7 individuals of the species *Telescopium telescopium*. The gastropod species found represent their habitats, which are the study locations. Gastropods of the species *Pomacea canaliculata* and *Pomacea diffusa* represent study locations with calm freshwater, while *Telescopium telescopium* gastropods were found around mangroves and muddy substrates (Abdunnur et al., 2023).

Gastropods from the family Ampullariidae are a group of freshwater mollusks commonly found in calm aquatic environments such as swamps, ditches, and slow-flowing rivers due to their ability to adapt to various types of habitats. Meanwhile, gastropods from the family Potamididae inhabit muddy coastal areas, particularly around mangroves and river estuaries. In this study, the presence of Potamididae gastropods, specifically *Telescopium telescopium* is closely associated with the mangrove ecosystem. These gastropods play a role as decomposers and detritus feeders, and they contribute to the sediment bioturbation process.

Types of Microplastics

Microplastics are defined as plastic particles smaller than 5 mm that can originate from primary sources (microbeads in cosmetic products) or secondary sources (the result of macroplastic degradation), while the most common types of microplastics are pellets, fragments, fibers, films, foams, and granules. In this study, the types of microplastics found include fibers, films, fragments, and granules (Figure 3). Microplastic characteristics are classified based on type, color, and size.

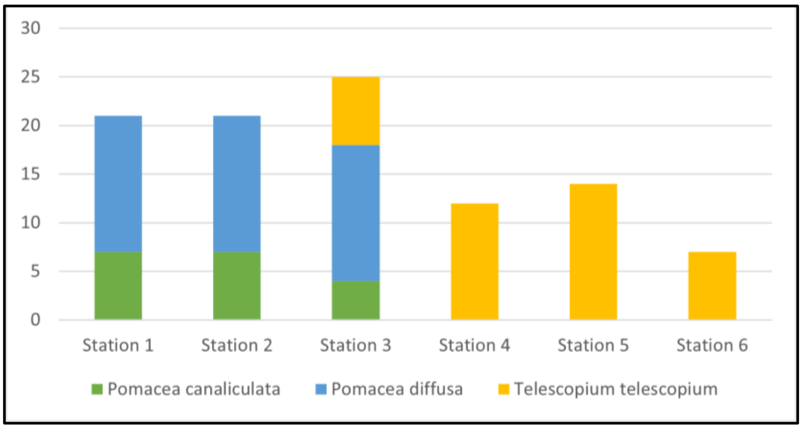

Figure 2. Species of Gastropods

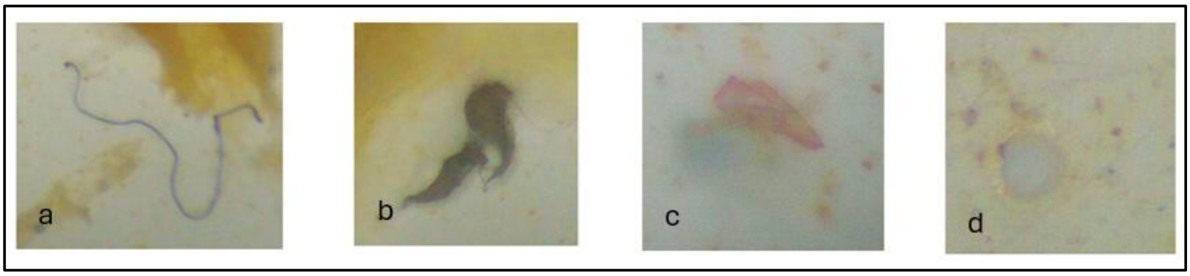

Figure 3. Types of Microplastics (a. Fiber, b. Film, c. Fragment, d. Granule)

Microplastics of the fiber type are the most commonly found type of microplastic, generally originating from ropes, nets, fabrics, and synthetic threads used as the main material for textile production in clothing. The size of this type of microplastic is very small, with a long and thin shape, enabling it to remain suspended in water and spread widely in the marine environment. Research conducted by Acharya et al. (2021) found that fiber-type microplastics are the most common type found in commercial fish stocks in the South China Sea and the Strait of Malacca.

The second most common type of microplastic found in this study was film-type microplastics, which are very thin and small and originate from the degradation of plastic sheets such as plastic bags and food packaging, making them easily carried by currents (Hidalgo-Ruz et al., 2012). This type of microplastic also has a low density, causing it to float on the surface and easily move from one location to another (Ayuningtyas et al., 2019). In addition, film-type microplastics can absorb and accumulate pollutants from their surroundings (Torres et al., 2021), which can increase toxicity for organisms that ingest them. Another type of microplastic found in this study is fragment-type microplastics, which resemble small plastic fragments resulting from degradation processes. This type of microplastic originates from bottles, plastic bags, and PVC pipes. As much as 90% of total microplastics in the ocean are the result of fragmentation of large plastic pieces, making them the most common type found in marine environments (Cole et al., 2011). This is supported by the statement from Barnes et al. (2009), who noted that microplastic fragments are the result of the breakdown of various everyday plastic products. Granul microplastics are the least common type of microplastics found in this study. These microplastics are spherical or cylindrical in shape and measure approximately 1-5 mm. Granules are the main raw material in the plastics industry and are used in various plastic products through melting and molding. Granul microplastics are classified as primary microplastics, which are microplastics that are intentionally produced in small sizes as raw materials for industry.

Color of Microplastics

Based on the results of the color observation in this study, it was found that the microplastic colors varied, indicating that they likely originated from various sources of pollution (Figure 4). Black was the most common color in gastropods, accounting for 32.1% of the total (Figure 5), where this color indicates a high level of toxicity and has undergone degradation or breakdown due to UV radiation and physical conditions of the sea (Shafani et al., 2022). Blue was the second most common color in this study, accounting for 23.3%, followed by red microplastics at 18.6%. These three colors indicate high contributions from plastic waste and domestic and industrial activities such as raffia ropes, fishing nets, and food packaging.

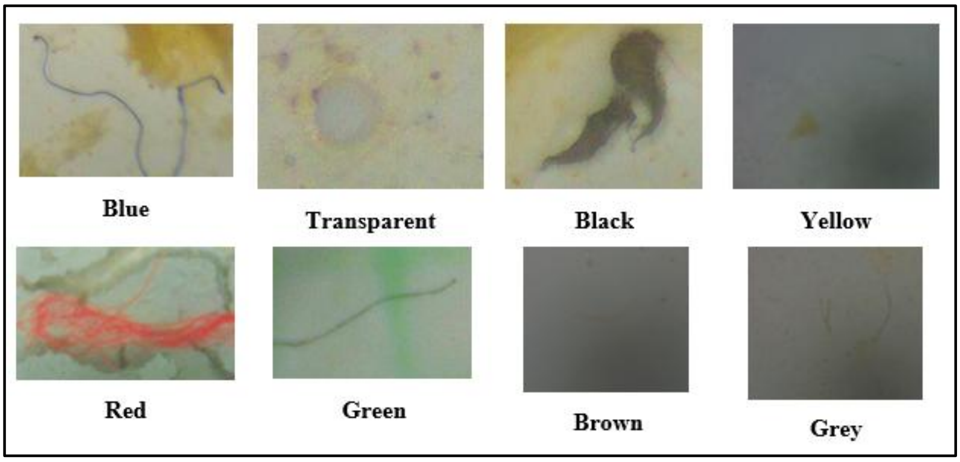

Figure 4. Color of Microplastics

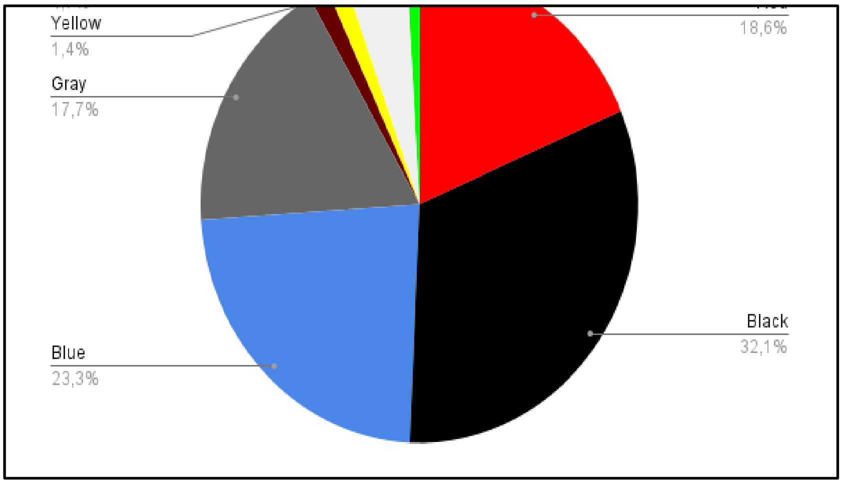

Figure 5. Percentage Color of Microplastics

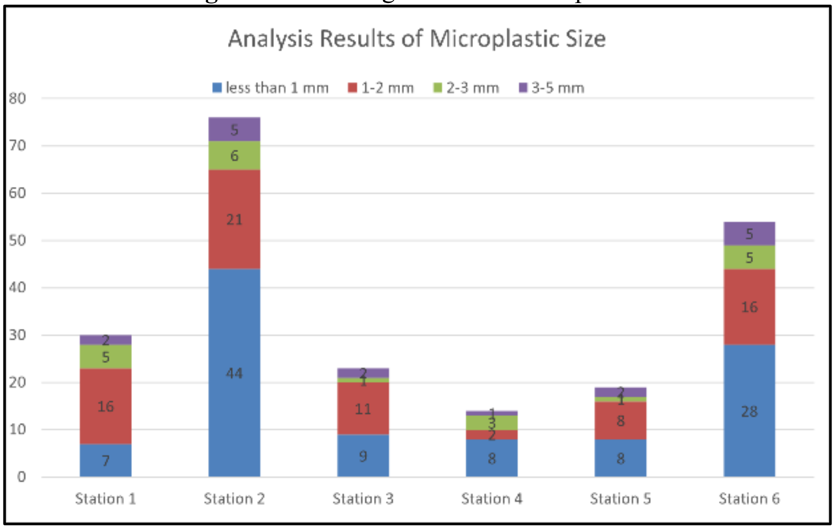

Figure 6. Analysis Results of Microplastic Size

Gray color was found with a percentage of 17.7%, likely originating from degraded plastic waste or synthetic materials, while transparent microplastics accounted for 4.7%, possibly from plastic bags and single-use water bottles. Additionally, transparent microplastics originate from microplastics that have undergone phytochemical processes causing the loss of pigment color in microplastics (Tubagus et al., 2020) and are predominantly found in film types (Kor et al., 2020). Meanwhile, yellow and green microplastics had the same percentage in this study, at 1.4%, and the microplastics with the smallest percentage found in gastropods in this study were green microplastics, at 0.9%.

Size of Microplastics

Station 2 is the station with the highest number of microplastics, with 44 particles measuring <1 mm, 21 particles measuring 1-2 mm, 6 particles measuring 2-3 mm, and 5 particles measuring 3-5 mm. Similarly, microplastic measurements at Station 6 showed higher levels of microplastics with sizes <1 mm (28 particles), 1-2 mm (16 particles), 2-3 mm (5 particles), and 3-5 mm (5 particles). Meanwhile, Station 1 had 7 particles of microplastics with a size of <1 mm, 16 particles of 1-2 mm, 5 particles of 2-3 mm, and 2 particles of 3-5 mm (Figure 6). This could be due to the station being located near residential areas and anthropogenic activities, which are the primary sources of microplastics.

Other results were obtained at stations 3, 4, and 5, which are located near ponds and mangrove vegetation, showing lower microplastic counts and more limited size variations. This may indicate the role of natural environments such as mangrove ecosystems as filters for suspended particles, including microplastics. Microplastics with sizes <1 mm are more commonly dominant because microplastics exposed to sunlight tend to fragment into smaller particles and are found in freshwater systems, oceans, soil, and air. Therefore, they have great potential to enter the food chain because they are easily ingested by marine biota. One factor that can cause this is that macroplastics tend to be easily carried by tidal currents, reducing the likelihood of macroplastics settling on the seabed (Tubagus et al., 2020).

Abundance of Microplastics

The highest microplastic abundance level was found at station 6 (Table 1), with 2,120 particles/gram, and a gastropod sample weight of 25.47 grams, indicating that station 6 (Estuary) has a location with fairly high microplastic contamination. The second-highest microplastic abundance was found at Station 2, with an abundance of 1,687 particles/gram, which also had the highest number of microplastics (76 particles) and the largest sample weight of 45.06 grams. Station 2 showed relatively high microplastic contamination, as the station is located near a river close to residential areas, which could lead to microplastic contamination from household activities, as well as a tourist area not far from the river flow.

Station 3 had a microplastic abundance of 1.274 particles/gram, indicating a higher microplastic abundance compared to Station 1, which had an abundance of 1.145 particles/gram. The location with the lowest microplastic abundance was at station 4, with 0.441 particles/gram, 14 particles, and a sample weight of 31.74 grams. Meanwhile, station 5 showed a microplastic abundance of 0.706 particles/gram, 18 particles, and a sample weight of 25.5 grams.

The results of microplastic analysis at Pasir Putih beach show that the gastropod sampling locations have varying levels of abundance. In waters near residential areas, namely stations 1 and 2, and in the estuary area, namely stations 5 and 6, which are directly connected to the sea, the abundance levels are high compared to locations near mangrove vegetation. High microplastic contamination is strongly suspected to be due to anthropogenic activities such as domestic waste disposal, tourism, and surface runoff carrying plastic particles into the water, as supported by previous research Falahudin et al. (2020) in Banten Bay, Lada Pandeglang Bay by Ukhrowi et al. (2021), and in Karimunjawa Island (Kurnianto et al., 2024). This is further supported by data released by SIPSN in 2024, which shows that the city of Serang generated 225, 318.46 tons, with 21,358.26 tons of waste successfully reduced and 135,707.00 tons of waste successfully managed, leaving 68,253.20 tons of waste yet to be managed.

Stations 4 located near mangrove vegetation exhibit lower levels of microplastic contamination. This is likely due to the reduced direct human activity in these areas, as well as the ecological role of mangroves, which act as natural filters for suspended particles, including microplastics. These microplastics can accumulate in various components of the mangrove ecosystem, as the sediment structure actively traps microplastic fibers and fragments (Mendes et al., 2023).

It is important to acknowledge the potential influence of survivorship bias on the observed microplastic abundance. Since this study sampled active, live gastropods, the results primarily reflect sub-lethal, chronic contamination levels tolerated by surviving individuals. Highly contaminated individuals that may have suffered acute physiological impairment or mortality prior to sampling were naturally excluded from the collected specimens. Consequently, the quantified microplastic abundance may represent a conservative estimation of the total environmental exposure. Nevertheless, evaluating live specimens remains ecologically relevant as it accurately measures the ongoing microplastic load within the active benthic food web, representing the actual exposure risk to higher trophic levels. Future studies combining field surveys with dead shell analysis or controlled laboratory toxicity assays are recommended to further elucidate lethal thresholds and population-level impacts.

Table 1. Total microplastic particles, sample weight, and microplastic abundance at each sampling station

Station	Total Microplastics (particle)	Sample Weight (gram)	Microplastics abundance (particle/gram)
1	30	26,20	1,145
2	76	45,06	1,687
3	23	18,05	1,274
4	14	31,74	0,441
5	18	25,50	0,706
6	54	25,47	2,120

Conclusion

Ampullariidae and Potamididae are the dominant gastropod families in Pasir Putih beach. The microplastics found in gastropods in Pasir Putih beach vary in color, with black being the dominating color, fiber-shaped microplastics being the most dominant, and sizes <1 mm being the most frequently found. The abundance of microplastics in gastropods was highest at Station 6, which is directly adjacent to the sea, at 2,120 particles/gram, while Station 4 had the lowest microplastic abundance among the other stations, with mangrove vegetation as the study site yielding 0.441 particles/gram.

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