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Composition, Types, and Abundance of Microplastics in Water, Sediments, and Blood Clams (*Anadara granosa*) in the Coastal Waters of Sinaboi, Rokan Hilir Regency

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ABSTRACT

Microplastics are plastic particles smaller than 5 mm that are difficult to degrade and tend to persist for long periods. This study aims to analyze the types and abundance of microplastics, as well as differences in abundance and their relationships in water, sediment, and blood clams (*Anadara granosa*). This study was conducted in the waters off Sinaboi Beach, Rokan Hilir Regency, and continued at the Marine Chemistry Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau. The method used was a survey employing a purposive sampling approach. The results of this study indicate that the composition of microplastic types found in the waters of Sinaboi Beach included fibers, fragments, films, foams, and granules (pellets); however, in the sediments and blood clams, only granules (pellets) were found. The average abundance of microplastics in water, sediment, and blood clams was 1,467 particles/L, 1,299 particles/g, and 6,844 particles/g, respectively. Statistical analysis showed that the abundance of microplastics in water, sediment, and blood clams based on sampling stations did not differ significantly ($p > 0.05$). Microplastic abundance in blood clams differed significantly from that in water and sediment ($p < 0.05$), whereas the comparison between water and sediment showed nearly equivalent abundance levels ($p > 0.05$). The strongest relationship was found between microplastic abundance in blood clams and sediment, showing a moderate positive correlation.

Keywords: Microplastics, Abundance, Water, Sediment, *Anadara granosa*, and Sinaboi Beach

1. INTRODUCTION

In 2024, a study published in Environmental Science and Technology found that Indonesia ranks among the top countries globally in per capita microplastic consumption. Researchers found that the majority of these microplastics come from drinking water and seafood (Zhao & You, 2024). The waters of Sinaboi Beach are located in Sinaboi Subdistrict, Rokan Hilir Regency, Riau Province. This area borders the Strait of Malacca and is home to a local community whose residents work primarily in the fishing industry. This makes Sinaboi Subdistrict a strategically important coastal region.

In addition, it is used by the local community as a site for fish processing, housing, and a fishing port. This area is one of the key centres of fishing activity and an important coastal zone in Rokan Hilir Regency. Sinaboi Subdistrict houses a major port that the local government once planned to develop into the main port of Bagansiapiapi City on a larger scale (Asfar et al., 2025). Plastic waste entering water bodies can originate from land or be disposed of directly into the water. Waste is the result of various human activities, including domestic, industrial, agricultural, and maritime activities. To date, plastic pollution has become a global environmental issue.

Microplastics are plastic particles smaller than 5 mm that are difficult to degrade and tend to persist for long periods (Hafitri et al., 2022). Microplastics are commonly found in the water column and sediments of both sandy and muddy coastal areas through mass transport. Microplastics are estimated to absorb more contaminants at the site, potentially leading to higher pollution concentrations due to longer particle residence times (Ibrahim et al., 2023).

The presence of microplastics in coastal marine environments harms local ecosystems. Microplastics can disrupt the food chain in coastal ecosystems through marine life. Additionally, microplastic particles can harm organisms living on the seafloor by becoming suspended and accumulating in sediments. The plastic problem requires serious attention because plastic waste can act as a persistent carrier, absorbing other hazardous pollutants. This can certainly have ecological effects, impact the health of humans who consume seafood, and affect the long-term persistence of these pollutants (Wicaksono et al., 2021).

High levels of human (anthropogenic) activity in the coastal area of Sinaboi Beach may increase the influx of plastic waste into the marine environment, potentially contaminating marine life. Microplastics can pose a threat because they can accumulate in the bodies of marine organisms, such as the blood clam (*Anadara granosa*), which is a filter feeder. Clams have become a primary marine catch for coastal communities. This is evidenced by the abundance of clams found in both domestic and international markets. Blood clams are even widely cultivated by the people of Rokan Hilir. Blood clams are not only consumed but also serve as an important fishery commodity with significant economic value (Asfar et al., 2025).

A study on microplastic pollution levels in the waters off Sinaboi Beach is urgently needed, as this area serves as a primary source of livelihood for the coastal communities of Sinaboi Beach, particularly through marine fisheries. According to data from the Riau Provincial Research and Innovation Agency, Rokan Hilir Regency is the largest producer of blood clams in Riau Province, with production reaching 6,492.47 tons in 2018 (Riza et al., 2024). This study examines pollution levels in the waters off Sinaboi Beach, focusing on the types and abundance of microplastics in water, sediments, and, particularly, in blood clams, the most commonly found species.

2. RESEARCH METHOD

Time and Place

This study was conducted from October to December 2025. Sampling was carried out in the waters off Sinaboi Beach, Sinaboi Subdistrict, Rokan Hilir Regency, Riau Province, at three stations. Sampling was conducted at three stations due to the high level of human activity in the area, including urban settlements, a port, and mangrove areas. Microplastic sample testing was conducted at the Marine Chemistry Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.

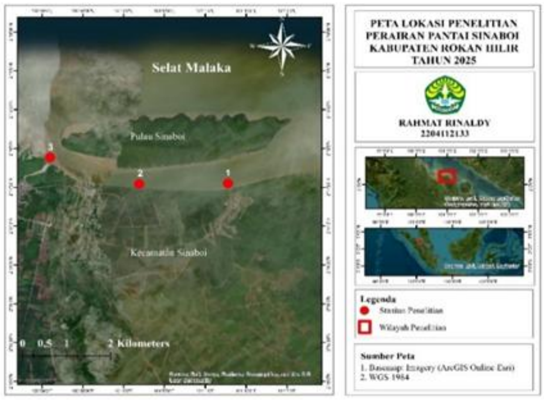

Figure 1. Map of Research Stations

Method

This study used a survey method with a quantitative descriptive approach. Primary data were obtained through field observations and laboratory analysis, while secondary data were obtained from literature studies.

Procedures

Water Sample

Seawater samples were collected at each station five times from different sampling points. Water samples were collected in a 20-L bucket at each sampling point and then filtered through a No. 25 plankton net at a rate of 100 litres per station. The filtered water samples were placed into 100 mL sample bottles, with a total of 1,500 mL collected. Sampling was conducted randomly during the neap tide, with sampling points spaced 10–20 meters apart. The samples were labelled and stored in an icebox (Pernanda et al., 2024). Analysis of microplastic abundance in seawater was performed using a filtration method based on NOAA guidelines (Masura et al., 2015), using the formula:

$$K = \frac{\text{Number of microplastic particles (Particle)}}{\text{Volume of filtered water (L)}}$$

Sediment Sample

Sediment sampling was conducted during low tide using a 4-inch PVC pipe 80 cm long at an average depth of 0–10 cm, with 500 g collected per station. Only the 0–5 cm surface layer of the sediment samples was analyzed. Sediment sampling was conducted five times at different sampling points spaced 10–20 meters apart, resulting in a total of 1,5 kg of samples collected. The samples were placed in plastic containers and labelled according to the station and sampling point. The samples were stored in an ice box to prevent damage and contamination (Pratiwi et al., 2025). The analysis of microplastic abundance in the sediment followed the method described by Nugroho et al. (2018) using the following formula:

$$K = \frac{\text{Number of microplastic particles (Particle)}}{\text{Dry weight of sediment(g)}}$$

Clams Sample

Sampling of blood clams was conducted at low tide at five sampling points at each station using a dredge. At each sampling point, one blood clam was collected at intervals of 10–20 meters across different locations, resulting in a total of 15 blood clam samples with shell sizes >3 cm, assuming the collected samples represented adult clams of a size consumed by the local community.

The determination of the number of blood clam samples required for this study was based on available time and resources (Lie et al., 2018; Pernanda et al., 2024). Samples were placed in plastic containers, labelled, and stored in an ice box. The analysis of microplastic abundance in blood clams was conducted using a filtration method based on NOAA guidelines (Leung et al., 2021), using the formula:

$$K = \frac{\text{Number of microplastic particles (Particle)}}{\text{Wet Weight of Clams (g)}}$$

Water Quality Measurement

This study utilized physical and chemical water parameters, namely temperature, salinity, pH, and current velocity. Data measurements were taken directly in the field.

3. RESULT AND DISCUSSION

Water Quality Parameters

The temperature measurements indicate that these values fall within the optimal tolerance range for the survival of blood clams. Water temperatures ranging from 29–30 °C are suitable for the growth and activity of blood clams. Riza et al. (2024) state that the optimal temperature range for blood clam growth is 28–30 °C. Additionally, temperature can accelerate the degradation of plastic particles into smaller pieces (photodegradation).

Table 1. Water Quality

Station	Temperature (°C)	Salinity (‰)	pH	Current (m/s)	
				High Tide	Low Tide
I	30	23	7,56	0,98	0,47
II	29	29	7,68	0,50	0,29
III	30	24	7,14	1,10	0,58

The salinity levels indicate that conditions remain suitable for blood clams; this is supported by Alburhana et al. (2023), who reported that optimal water quality for the survival and growth of blood clams is a salinity range of 22–30 ‰. Additionally, salinity can influence the abundance of microplastics in aquatic environments. Microplastics float more easily in marine waters with high salinity than in freshwater, due to seawater's higher density.

The pH value obtained is considered suitable for blood clam growth. According to Alburhana et al. (2023), a pH range of 6–9 falls within the normal range and is suitable for blood clams in aquatic environments. pH is one of the key factors determining whether blood clams can thrive in a given body of water. Additionally, acidic pH levels can accelerate the degradation of microplastics.

Current speeds in the coastal waters of Sinaboi are strong during high tide and moderate during low tide, which can influence the distribution of microplastics at the study site. Strong currents will carry all present particles, including microplastics, to wider areas. Meanwhile, moderate or weak currents allow microplastic particles to be transported and deposited on the seabed without causing excessive resuspension. This will certainly affect filter-feeding organisms such as blood clams, which accumulate food through water particles and sediments (Amin et al., 2020).

Composition Types and Percentage of Microplastics

The results of the analysis of microplastic types found in the waters off Sinaboi Beach revealed the presence of fibers, fragments, films, foam, and granules (pellets) in the water (Figure 2); however, in the sediment (Figure 3) and blood clams (Figure 3), only granules (pellets) were not detected. Based on the composition

data, fibers accounted for a significantly higher percentage than other microplastic types, at 53.64% (Figure 5).

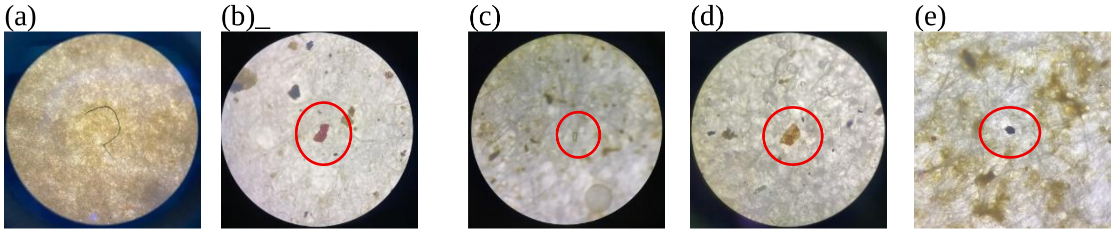

Figure 2. Composition of Microplastic Types in Water, (a) Fiber, (b) Fragment, (c) Film, (d) Foam, and (e) Granules (pellets)

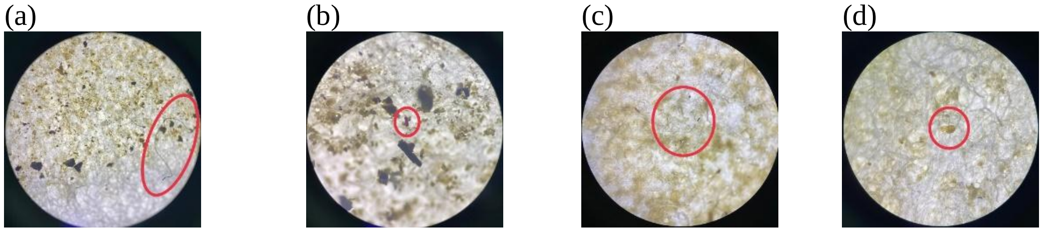

Figure 3. Composition of Microplastic Types in Sediment, (a) Fiber, (b) Fragment, (c) Film, and (d) Foam

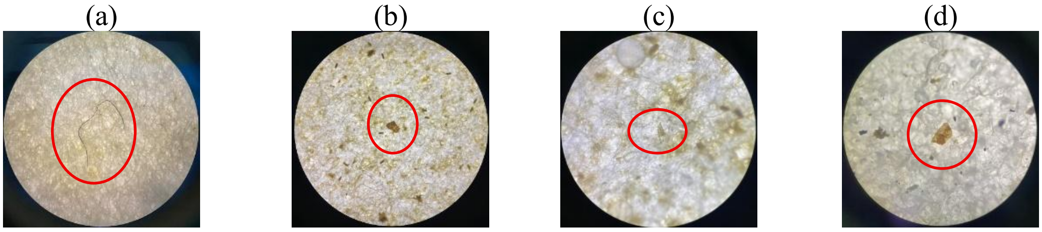

Figure 4. Composition of Microplastic Types in Blood Clam (*A. granosa*), (a) Fiber, (b) Fragment, (c) Film, and (d) Foam

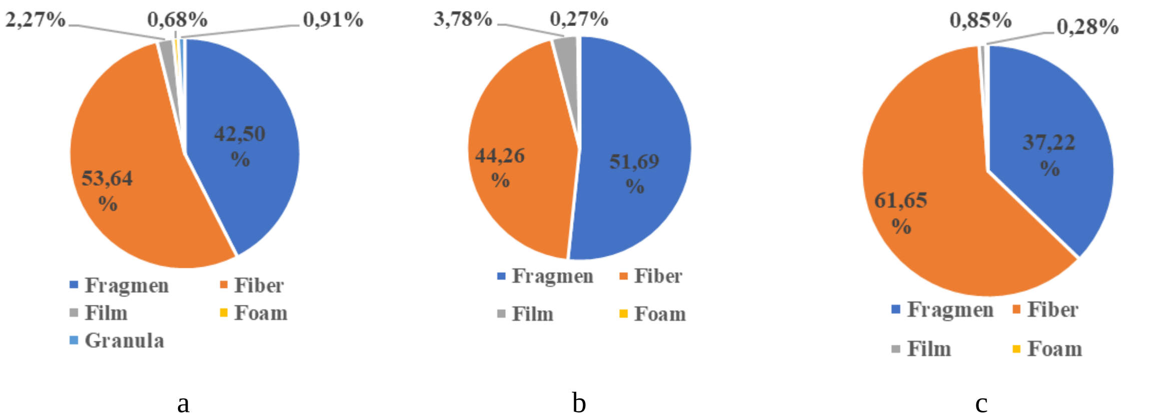

Figure 5. Percentage Composition of Microplastic Types, notes: (a) Water, (b) Sediment, and (c) Blood Clam (*A. granosa*)

The results of the analysis of microplastic types found in the waters off Sinaboi Beach revealed the presence of fibers, fragments, films, foam, and granules (pellets) in the water (Figure 2); however, in the sediment (Figure 3) and blood clams (Figure 3), only granules (pellets) were not detected. Based on the composition data, fibers accounted for a significantly higher percentage than other microplastic types, at 53.64% (Figure 5).

The prevalence of fiber-type microplastics at the study site is most likely due to human and fishing activities, as well as environmental factors such as water quality, which can degrade microplastics, which are then carried by currents and waves (Mardiyana & Kristiningsih, 2020). These results align with a study by Febriani et al. (2020) in Bengkalis waters, which found that fiber-type microplastics were the most dominant, accounting for nearly 70% of all types. This is further supported by the findings of Pratiwi et al. (2025), who noted that fiber-type microplastics are relatively common in aquatic environments due to their lightweight nature and their origin from the degradation of various fishing activities, including fishing gear and boat ropes that enter the water.

The high proportion of fragment-type microplastics in the sediment (51.69%) is believed to originate from commercial and household waste at the study site (Figure 5). Romaskila et al. (2023) also explain that fragment-type microplastics originate from plastic bottles and takeout containers that enter water bodies and degrade into small fragments.

Based on the percentage composition data (Figure 5), it is evident that in blood clams, fiber accounts for 61.65% and fragments for 37.22%, which still far outweigh other types of microplastics. Marine organisms such as clams often use filtration to obtain food from the water, so it is possible that microplastics in the water, whether in the water column or in sediments, will enter the bodies of biota such as blood clams (Setälä et al., 2016).

Fiber was the most prevalent type of microplastic found in the body tissues of blood clams. The prevalence of fiber in blood clams aligns with their feeding mechanism as filter feeders, that is, they filter particles from the water column, where finer particles resembling food easily enter their body tissues (Yona et al., 2021). Furthermore, the prevalence of fiber fragments in blood clams likely stems from fishing gear and lines made of synthetic fabrics or plastic sacks that are intentionally or unintentionally discarded into the ocean (Pernanda et al., 2024).

The presence of a significant number of these fragments in the blood clam's body indicates that this organism can also filter larger particles. Fragments originating from household and commercial waste can accumulate within the bodies of marine organisms (Ningrum et al., 2022). This aligns with the blood clam sampling locations, which are near urban areas, ports, and fishing communities.

Film and foam microplastics had very low percentage values. These results are consistent with a study by Yesika et al. (2025), which found that film and foam microplastics were also present in the bodies of bivalves, including blood clams, in the mangrove ecosystem of Tanah Mea Village, Donggala Regency, at very low levels. This is because these types of microplastics, plastic film, and foam tend to float and be carried by currents, so they rarely accumulate in the bodies of marine organisms such as clams and oysters, which live buried in the sediment.

Granular (pellet) microplastics, which were not found in sediments or blood clams, are suspected to originate from the relatively low use of cosmetic products and personal care items. This aligns with the findings of a study on blood clams in the waters of Banyuurip Village, Gresik, by Yona et al. (2021), which also did not detect granular (pellet) microplastics. These results are further supported by the findings of Agnes et al. (2024), who noted that granule-type microplastics (pellets) are found only at the water's surface and rarely in sediments where marine organisms such as blood clams reside. Overall, these results indicate that fibers and fragments are the primary types of microplastics in the waters off Sinaboi Beach, Rokan Hilir Regency

Microplastic Abundance by Station

The average microplastic abundance in water, sediment, and blood clams was 1,467 particles/L (Table 2), 1,299 particles/g (Table 3), and 6,844 particles/g (Table 4), respectively. The highest abundance in water was found at Station III with a value of 1,580 particles/L (Table 2). The high abundance of microplastics at this location is likely due to extensive fishing activities, including port operations, commercial fishing, and domestic activities. This is compounded by the fact that the majority of the local population works in the fisheries sector. Furthermore, there is strong evidence of intensive anthropogenic activity around the estuary, given its role as a primary transportation route and the presence of port activities in the surrounding area.

This is supported by a study conducted at the Demak River Estuary (Pamungkas et al., 2022), which found that microplastic abundance in water is generally higher in river estuaries than in open coastal waters due to differences in hydrodynamic characteristics. According to Damanik et al. (2024), high pollutant accumulation at river mouths is caused by differences in density: freshwater has a lower density than seawater, and their interaction drives circulation. Based on the results of the One-Way ANOVA test, there was no significant difference in microplastic abundance in the water across stations, as indicated by a p-value > 0,05. The highest average microplastic abundance in the sediment was found at Station I, with a value of 1,497 particles/g (Table 3); this location is generally situated near urban residential areas and is influenced by port activities.

Table 2. Microplastic Abundance in Water

Types Mikroplastics	Station 1	Station 2	Station 3	On Average
Fiber	0,760 ± 0,357	0,750 ± 0,451	0,850 ± 0,262	0,787 ± 0,341
Fragment	0,530 ± 0,164	0,680 ± 0,258	0,660 ± 0,221	0,623 ± 0,213
Film	0,020 ± 0,040	0,020 ± 0,027	0,060 ± 0,065	0,034 ± 0,048
Foam	-	0,020 ± 0,065	0,010 ± 0,010	0,010 ± 0,020
Granules	0,030 ± 0,027	0,010 ± 0,022	-	0,013 ± 0,022
Total	1,340 ± 0,424	1,480 ± 0,673	1,580 ± 0,216	1,467 ± 0,452

Table 3. Microplastic Abundance in Sediment

Types Microplastics	Station 1	Station 2	Station 3	On Average
Fiber	0,636 ± 0,246	0,560 ± 0,273	0,522 ± 0,115	0,572 ± 0,211
Fragment	0,820 ± 0,356	0,550 ± 0,140	0,654 ± 0,065	0,677 ± 0,262
Film	0,032 ± 0,010	0,078 ± 0,043	0,034 ± 0,023	0,048 ± 0,034
Foam	0,004 ± 0,004	0,004 ± 0,008	-	0,002 ± 0,007
Granules	-	-	-	-
Total	1,492 ± 0,423	1,192 ± 0,340	1,210 ± 0,171	1,299 ± 0,335

Table 4. Microplastic Abundance in Blood Clam

Types Mikroplastics	Station 1	Station 2	Station 3	On Average
Fiber	4,128 ± 1,317	4,058 ± 1,439	4,358 ± 0,818	4,181 ± 1,138
Fragment	2,966 ± 0,543	2,442 ± 0,941	2,326 ± 0,624	2,578 ± 0,729
Film	0,134 ± 0,299	-	0,060 ± 0,134	0,064 ± 0,184
Foam	-	0,060 ± 0,134	-	0,020 ± 0,077
Granules	-	-	-	-
Total	7,228 ± 1,394	6,560 ± 0,693	6,744 ± 0,905	6,844 ± 1,006

This location is also home to the main port of the Sinaboi subdistrict, where fishing activity is naturally high. Furthermore, it is strongly suspected that there are intensive anthropogenic activities in this area, given its proximity to a densely populated, bustling urban area. This is supported by the findings of Novadah et al. (2025) along the coast of Manado Bay, which indicate high microplastic abundance in sediments in densely populated areas with various fishing activities, including those by fishermen, as well as from domestic waste. The higher the level of human activity in the area, the greater the potential for plastic pollution. Based on the results of the one-way ANOVA test, there was no significant difference in microplastic abundance in the sediment among the stations, as indicated by a p-value > 0,05.

Abundance of Microplastics in Water, Sediment, and Blood Clams

Differences in the average abundance of microplastics in water, sediment, and blood clams off Sinaboi Beach indicate that the characteristics of each medium influence the dynamics of microplastic distribution and accumulation. In general, the highest microplastic abundance was found in blood clams, followed by water, and the lowest in sediment. This pattern indicates that benthic organisms, particularly blood clams, act as microplastic accumulators from their surrounding environment. The high abundance of microplastics in blood clams, at 6,844 particles/g, is closely related to their biological nature as filter-feeding organisms that obtain food by filtering suspended particles from the water column and surface sediments. This filtration process allows small microplastics to accumulate within the mussel's body tissues (Yona et al., 2021).

Table 5. Differences in the Average Abundance of Microplastics

Types Microplastic	Water (Particle/L)	Sediment (Particle/g)	Blood Clam (Particle /g)
Fiber	0,787 ± 0,341	0,572 ± 0,211	4,181 ± 1,138
Fragment	0,623 ± 0,213	0,677 ± 0,262	2,578 ± 0,729
Film	0,034 ± 0,048	0,048 ± 0,034	0,064 ± 0,184
Foam	0,010 ± 0,020	0,002 ± 0,007	0,020 ± 0,077
Granules	0,013 ± 0,022	-	-
Total	1,467 ± 0,452	1,299 ± 0,335	6,844 ± 1,006

Based on the results of the one-way ANOVA and the Games-Howell post-hoc test, the comparison of blood clam abundance between water and sediment was found to be significantly different ($p < 0,05$). Conversely, water and sediment exhibited relatively similar abundance patterns or were not significantly different ($p > 0,05$). This difference indicates that the distribution of microplastics is not uniform across environmental compartments. Ecologically, blood clams, as organisms that live on the aquatic substrate and act as filter feeders, tend to accumulate microplastic particles from the water column and sediment through nutrient filtration; thus, the concentration of microplastics in their bodies may differ from that of their surrounding environment.

These findings are supported by research by Rochman et al. (2015), which indicates that bivalves have a high potential to accumulate microplastics compared to other environmental media, due to their feeding activities and limited ability to excrete foreign particles. Additionally, blood clams tend to burrow into muddy substrates, which generally serve as deposition zones for various particles, including microplastics, thereby increasing continuous exposure.

Relationship between Microplastic Abundance in the Waters off Sinaboi Beach

The results of the linear regression analysis between microplastic abundance in water and sediment showed a positive correlation with a correlation coefficient of r = 0,336 and a coefficient of determination of R^2 = 0,1129. These values indicate that only about 11,29% of the variation in microplastic abundance in sediments can be attributed to water. At the same time, the remainder is influenced by other environmental factors. These results align with a study conducted on the coast of Pandan Subdistrict, Tapanuli Tengah Regency, North Sumatra Province, by Yani et al. (2021), which found that the relationship between microplastic abundance in water and sediment is relatively weak, with only 11% of the variation in sediment microplastic abundance explained by water microplastic abundance, while 89% is attributed to other factors such as current velocity, which can transport plastic from the shoreline to the open sea. The linear regression graph of the relationship between microplastic abundance in water and sediment is shown in Figure 6.

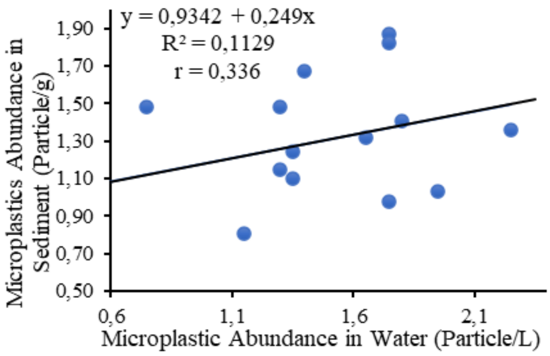

Figure 6. The Relationship between Microplastic Concentrations in Water and Sediment

The results of the linear regression analysis between microplastic abundance in water and blood clams showed a positive relationship with a correlation coefficient of r = 0,267 and a coefficient of determination of R^2 = 0,0714. These values indicate that only about 7,14% of the variation in microplastic abundance in blood clams can be attributed to waterborne microplastics, while other environmental factors influence the remainder.

These results are consistent with a study by Pernanda et al. (2024) on the Dudat River in Belitung Regency, which found that the correlation between microplastic abundance in water and the freshwater mussel (*Pilsbryoconcha exilis*) was relatively weak compared to that in sediment. This statement is also supported by Leppes et al. (2025), who noted that biological variation among individual clams or sampling conditions often results in weak or insignificant statistical relationships.

This weak correlation can be explained by the biological characteristics of the blood clams, which live and forage on muddy substrates. Blood clams not only utilize water as a food source but also interact intensively with the sediment; thus, the microplastics accumulated in their bodies do not fully reflect the microplastic conditions in the water column at the time of sampling. A linear regression graph of the relationship between microplastic abundance in water and in sediment is shown in Figure 7.

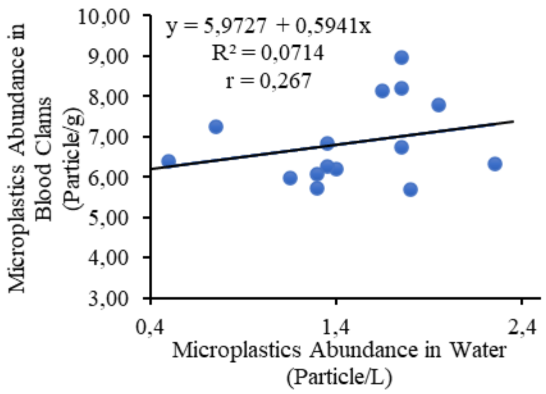

Figure 7. The Relationship between Microplastic Abundance in Water and the Blood Clam (*A. granosa*)

The results of the linear regression analysis between microplastic abundance in sediment and the blood clam showed a positive relationship, with a correlation coefficient of r = 0,418 and a coefficient of determination of R^2 = 0,1751. These values indicate that only about 17,51% of the variation in microplastic abundance in blood clams can be attributed to sediment microplastic abundance. At the same time, the remainder is influenced by other environmental factors. This relationship is moderate because the blood clam is a benthic organism that prefers to live buried in muddy sediment, resulting in more intensive interaction with the sediment (Yona et al., 2021).

This is consistent with research by Pratiwi et al. (2023) on Bangka Island, which found that benthic bivalves showed a stronger correlation with microplastics in sediments than in water. Additionally, Azizah et al. (2020) state that sediment is the primary pathway for microplastics to enter benthic organisms through direct ingestion and particle resuspension, thereby providing a more representative picture of pollution as an indicator than water. This explanation is further supported by the findings of Tuhumury & Agustina (2020), who noted that the blood clam belongs to a group of marine organisms with slow mobility, living sedentarily in sediments or on the seafloor, thereby facilitating more intensive bioaccumulation and bioconcentration. A linear regression graph of the relationship between microplastic abundance in water and sediment is shown in Figure 8.

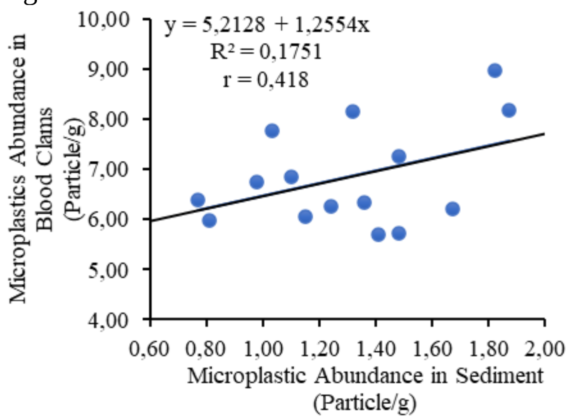

Figure 8. The Relationship between Microplastic Abundance in Sediment and the Blood Clam (*A. granosa*)

4. CONCLUSION

Based on this study, it was concluded that the types of microplastics found in the waters off Sinaboi Beach included fibers, fragments, films, foam, and granules (pellets); however, in the sediments and blood clams, only granules (pellets) were not detected. Based on the stations, the highest microplastic abundance in the water was found at Station III with a value of 1,580 particles/L, while in sediments and blood clams, the highest average abundance was found at Station I, with a value of 1,492 particles/g for sediments and 7,288 particles/g for blood clams. These results did not show significant differences between stations (p-value > 0.05). The abundance of microplastics in blood clams differed significantly from both water and sediment ($p < 0.05$), whereas the comparison between water and sediment showed nearly equal abundance levels ($p > 0.05$). The strongest relationship was observed between microplastic abundance in blood clams and sediment, showing a moderate positive correlation.

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