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Analysis of Microplastic Types and Abundance in Water, Sediments, and Lokan Clams (*Geloina erosa*) in the Coastal Waters of Sinaboi, Rokan Hilir

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ABSTRACT

The objective of this study is to identify the species and abundance in the water, sediment, and the lokan clam to determine differences in abundance among the water, sediment, and the lokan clam and to examine the relationship between abundance in the water and sediment and the abundance of the lokan clam. This study was conducted from October to December 2025 in the waters off Sinaboi Beach. The methods used in this study were a survey and purposive sampling, with samples collected directly at the study site. Sample analysis was performed at the Marine Chemistry Laboratory, Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, Universitas Riau. Samples were collected from three types of test materials: water, sediment, and lokan clam from the waters off Sinaboi Beach. The results of the study showed that environmental parameters ranged from 7.38–8.20 for pH, 29–31°C for temperature, 24–29‰ for salinity, and 0.50–1.21 m/s for current velocity. Four types of microplastics were found in the water, sediment, and lokan clam: fibers, fragments, films, and foam. The average microplastic abundance in water was 0.45 particles/L. In sediment, it was 1.74 particles/g. The average microplastic abundance in lokan clam was 2.20 particles/g. Statistical analysis indicates a significant difference in microplastic abundance in water, sediment, and the lokan clam ($p < 0.05$). Microplastic abundance in sediment and the lokan clam shows a stronger correlation because clams are filter-feeding organisms that accumulate microplastics from sediment

Keywords: Microplastics, Abundance, Water, Sediment, *Geloina erosa*, Sinaboi waters

1. INTRODUCTION

Waste poses a challenge for communities around the world, including both land-based and marine waste. One of the most common types of waste found on land and in the ocean is plastic waste. Pollution caused by plastic waste has become a major global concern, particularly in marine environments, as the amount of waste entering the ocean each year continues to rise. Plastic waste degrades in water, breaking down into small plastic particles known as microplastics (Amin et al., 2020). Microplastics formed through this degradation process can take the form of fragments, fibers, films, and pellets of varying sizes. Microplastics in aquatic environments are extremely difficult to break down naturally and can therefore persist for long periods. As a result, microplastics enter the food chain through aquatic organisms, ultimately impacting both ecosystem health and human health.

Meanwhile, the indirect impact of microplastics on ecosystems is that they can affect the food chain and the ecosystem as a whole. Organisms exposed to microplastics can become prey for larger predators, allowing microplastics to move up the food chain. This has the potential to cause harmful substances to accumulate in predators' bodies, affecting human health when consumed. Additionally, microplastics can alter the physical and chemical properties of the environment, degrade water and soil quality, and disrupt species interactions (Galloway & Lewis, 2017).

The waters off Sinaboi Beach are a coastal area with relatively high levels of human activity, including settlements, fishing, and shipping, which could contribute to microplastic pollution entering the aquatic environment. Microplastics present in water can be distributed across various environmental compartments, including water, sediment, and aquatic organisms. One of them is the *Geloina erosa* clam, a filter feeder that has the potential to accumulate microplastics in its body. However, information regarding the types and abundance of microplastics in water, sediments, and the lokan clam in the waters off Sinaboi Beach remains limited. It has not been extensively studied to date.

Based on these considerations, this study aims to analyze the abundance of microplastics in water and sediment, and in the lokan clam, in the coastal waters of Sinaboi, through an assessment of their types and abundance. The results of this study are expected to provide additional scientific information and references regarding the types and abundance of microplastics in water, sediment, and the lokan clam, and the relationship between these factors can serve as a basis for formulating sustainable management strategies for the Sinaboi coastal waters, as well as for further studies on the distribution and accumulation of microplastics in benthic organisms in the waters of Sinaboi Beach, Rokan Hilir.

2. RESEARCH METHOD

Time and Place

This study was conducted in October 2025 in the waters off Sinaboi Beach, Rokan Hilir, Riau Province, Indonesia. Sampling and water quality measurements were performed directly at the study site. Analysis and identification of microplastic types and abundance were conducted at the Marine Chemistry Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences. The map of sampling locations is shown in Figure 1.

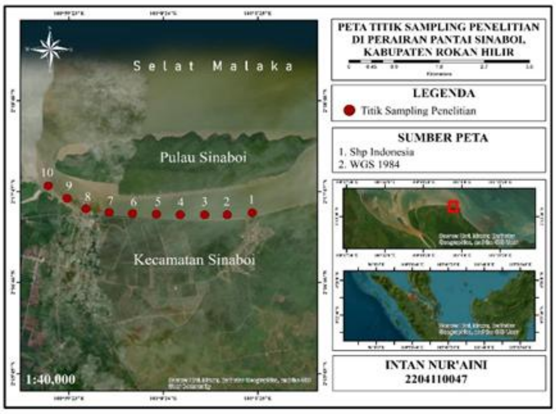

Figure 1. Research Location Map

Method

This study employed survey and purposive sampling methods, involving direct sampling at the research site. The data collected consisted of primary data obtained from surveys conducted in the waters off Sinaboi Beach, Rokan Hilir.

Procedures

Sampling points for water, sediment, and *G. erosa* were determined at 10 distinct locations to comprehensively represent conditions in the waters off Sinaboi Beach, accounting for environmental variations including differences in coastal activities, substrate characteristics, and water hydrodynamics. The sampling points were distributed evenly across the Sinaboi Beach area, with approximately 300 m between points, thereby covering the spatial variation in water quality from areas adjacent to community activities to those with minimal anthropogenic activity.

Sampling was conducted on three types of test materials: water, sediment, and lokan clam along the shoreline of Sinaboi Beach. Water samples were collected using sample bottles at depths of 0–30 cm to represent water conditions. Sediment samples were collected by taking bottom substrate samples in the area between high and low tide. Meanwhile, the collection of lokan clam was carried out with the assistance of local fishermen who are accustomed to harvesting clams at that location, ensuring representative samples were obtained under conditions consistent with the clams' natural habitat.

Microplastic Sampling in Water

Water sampling in this study was conducted using a plankton net and a bucket. Microplastic samples were collected from 10 different sampling points. Water samples were collected in a 20-L bucket and filtered through a plankton net. The filtered water samples were placed into 100 mL sample bottles, with a total of 10 bottles collected (Seftianingrum et al., 2023). Water samples were collected randomly, with each sampling point spaced approximately ±300 meters apart. The water samples were then stored in a cool box for analysis in the laboratory According to Masura et al. (2015), the abundance of microplastics in water samples can be calculated using the following formula:

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

Sampling of Microplastics in Sediment

Sediment sampling was conducted on the sediment surface using a spatula. Sediment was collected at each sampling point to a depth of 0–10 cm until approximately 200 g of sediment was obtained (Manalu, 2017). The distance between sediment sampling points was ±300 meters, and a total of 2 kg of sediment was collected. Each sediment sample was placed in a plastic container and labeled, then analyzed at the Marine Chemistry Laboratory.

Based on research conducted by Nugroho (2018), the abundance of microplastics in sediment can be calculated using the following formula:

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

Sampling of Microplastics in the *G. erosa*

Sampling of the lokan clam was conducted during low tide at each sampling site using a dragnet commonly used by fishermen. In this study, clams with a relative size of 5,6–6,2 cm were collected. One individual was collected at each sampling point, spaced approximately 300 meters apart, resulting in a total of 10 lokan clam required for this study. The collected clam samples were then placed in plastic containers and a cool box, and subsequently analyzed at the Marine Chemistry Laboratory.

Based on research conducted by Digka (2018), the abundance of microplastics in clams can be calculated using the following formula:

$$\text{Abundance MP} = \frac{\text{Number of microplastic particles (particles)}}{\text{Wet weight of sellfish (g)}}$$

Measurement of Water Quality Parameters

The measurement of water quality parameters in this study utilized physical and chemical water parameters, namely pH, temperature, salinity, and current velocity. Data measurements were conducted directly in the waters off Sinaboi Beach, Rokan Hulu Parameters include temperature (thermometer), pH (pH meter), salinity (refractometer), brightness (Secchi disk), and current (current meter).

3. RESULT AND DISCUSSION

Water Quality Parameters

Based on the water quality measurements at Sinaboi Beach presented in Table 1, variations in parameter values were observed across the 10 sampling points. The water pH ranged from 7,38 to 8,20. These values indicate that the water conditions tend to be neutral to slightly alkaline, which still falls within the optimal range for the survival of the lokan clam.

Table 1. **Water Quality Parameters**

Ts	Temp (°C)	salinity (‰)	pH	velocity (m/s)
1	30	24	7,56	0,98
2	30	24	7,61	0,90
3	30	25	7,59	0,79
4	31	28	8,11	0,50
5	31	28	8,20	0,62
6	31	29	7,67	0,66
7	29	25	7,38	0,71
8	30	25	7,66	0,87
9	29	24	7,72	1,09
10	29	24	7,64	1,21

The measured water temperatures ranged from 29–31 °C, with the highest recorded at points 4, 5, and 6 at 31 °C, while the lowest, 29 °C, was found at several other points. The results of temperature measurements at each sampling point indicate that this range reflects the characteristics of tropical waters and remains within the tolerance limits for most aquatic organisms, making it suitable for the survival of aquatic life, including the lokan clam. This relatively stable pH value indicates that the water possesses good buffering capacity.

The salinity of the water ranges from 24 to 29 ‰, with the highest value recorded at Point 6 at 29 ‰ and the lowest at several other points at 24 ‰. These variations in salinity indicate the influence of environmental factors, such as seawater mixing and possible freshwater inflow at the study site.

The water current velocity at Sinaboi Beach shows considerable variation, ranging from 0,50 to 1,21 m/s. The highest current velocity was recorded at point 10 at 1.21 m/s, while the lowest current velocity was recorded at point 4 at 0,50 m/s. This difference in current velocity is believed to be influenced by tidal conditions and by physical factors such as wind and seabed topography.

Types of Microplastics

Based on the results, this study demonstrates the presence of microplastics in water (Figure 2), sediment (Figure 3), and the *G. erosa* clam (Figure 4), comprising four types: fibers, fragments, films, and foam. In the water samples, fragmented microplastics accounted for the highest percentage, reaching 52% (Figure 5). This dominance can be attributed to several environmental factors, as well as to physical, chemical, and biological degradation processes.

Specifically, exposure to ultraviolet light (photodegradation), waves, and friction with other particles causes plastic to break down into small, irregular pieces. As a result, fragments are commonly found in water bodies. These fragments originate from residents' domestic activities, including discarded bottles, food containers, used jars, plastic folders, and PVC pipe fragments. Notably, this observation aligns with research conducted in Laguna, Pekalongan Regency, by Khanza et al. (2025), which found that fragments were the most common microplastic type in the water, originating from domestic waste and the batik industry, with a concentration of 4.72 particles/L.

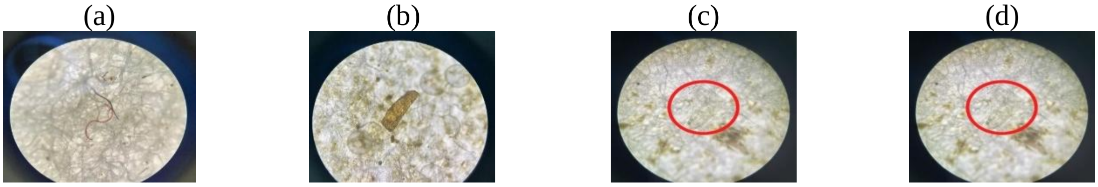

Figure 2. Types of Microplastics in Water, (a) Fibers, (b) Fragments, (c) Films, (d) Foam

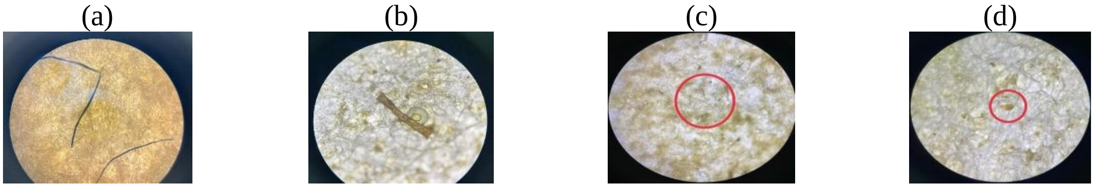

Figure 3. Types of Microplastics in Sediment, (a) Fibers, (b) Fragments, (c) Films, (d) Foam

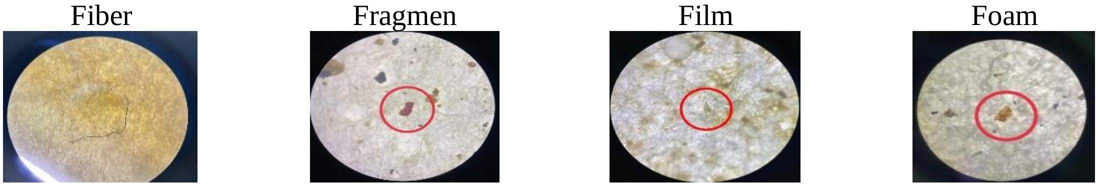

Figure 4. Types of Microplastics in Locan Clams: (a) Fibers, (b) Fragments, (c) Films, (d) Foam

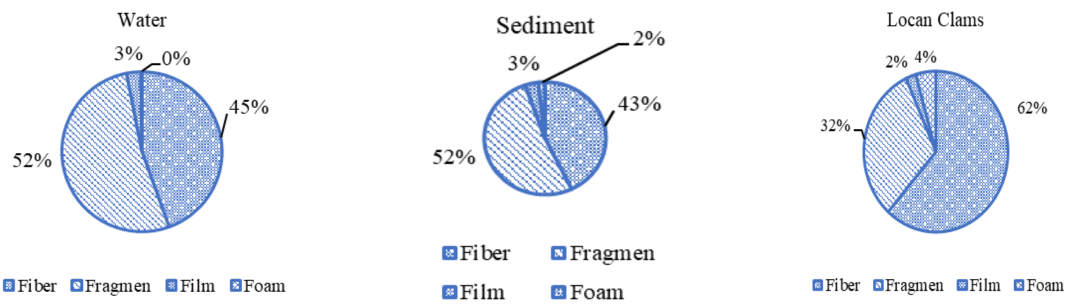

Figure 5. Percentage of Microplastics in Water, Sediment, and Clams

Similarly, fragmented microplastics also dominated the sediment, accounting for 52% of the total (Figure 5). The prevalence of fragmented microplastics in Sinaboi Beach sediments is attributed to the substantial amount of solid plastic waste that has degraded into small particles. According to Ayuningtyas et al. (2019), aquatic waste from various human activities contributes to microplastic pollution in household waste. Furthermore, the large population in the Sinaboi Beach area has increased plastic waste, and discarded household items continue to pollute the environment.

In contrast to water and sediment, fiber was the most commonly detected microplastic type in the lokan clam, accounting for 62% (Figure 5). The dominance of fiber-type microplastics in the lokan clam is due to their lightweight, small size, and ease of suspension in the water column, which facilitates their filtration by the lokan clam. This filter-feeding organism consumes particles such as fibers as a food source. Supporting this, research by Sari et al. (2021) in Bengkalis waters also found that fiber was dominant in *G. erosa*, with a concentration of 10,325 particles/g.

Apart from fibers and fragments, film and foam microplastics were also found in the bodies of clams, believed to stem from the disposal of single-use plastic bags and styrofoam at the study site. These observations are consistent with a study by Junaidi et al. (2024), which reported that film and foam microplastics were found in the bodies of bivalves, including the lokan clam, in the Kuala Langsa mangrove ecosystem, albeit at low levels. Because film and foam microplastics are lightweight, they tend to float and be carried by currents. Consequently, film and foam rarely accumulate in the bodies of organisms such as the erosa clam, which lives buried in the mud.

Microplastic Abundance by Sampling Point

Based on the data in Table 2, the types of microplastics found in the waters off Sinaboi Beach include fibers, fragments, films, and foam. The average abundance of microplastics in the water was 0,45 particles/L. The physical properties of microplastics and water dynamics influence this condition. Most microplastics, particularly fragments and fibers, have a relatively low density and therefore tend to float or remain suspended in the water column. These results differ from those of Thalita's (2023) study in Lake Poso, Central Sulawesi, which reported a microplastic abundance of 0.79 particles/L. The high abundance of microplastics in Lake Poso is suspected to be related to the intensity of activities in the coastal area, which allows microplastics to enter and be readily distributed throughout the water.

Table 2. Abundance of Microplastics in Water, Sediment, and the Lokan Clam *(G. erosa)* in the Waters off Sinaboi Beach

Sample	Abundance				Total Abundance
	Fiber	Fragment	Films	Foam	
Water (Particle/L)	0,20 ± 0,05	0,24 ± 0,09	0,01 ± 0	0 ± 0	0,45 ± 0,09
Sediment (Particle/g)	0,75 ± 0,53	0,90 ± 0,46	0,06 ± 0,10	0,03 ± 0,01	1,74 ± 1,10
Clams Locan (Partikel/g)	1,38 ± 0,60	0,68 ± 0,19	0,05 ± 0,08	0,09 ± 0,15	2,20 ± 1,02

The average abundance of microplastics in the sediment was 1,74 particles/g. The presence of microplastics in the sediment is believed to originate from those in the water column, which eventually settle to the bottom of the water body. These results are generally consistent with the study by Ningrum et al. (2022) on Gili Island, Probolinggo, which reported microplastic abundance in sediments ranging from 1,18 to 1,64 particles/g. Microplastic abundance in sediments is lower than in whelks but higher than in water, reflecting the distinct roles and characteristics of each medium.

The abundance of microplastics in the lokan clam, with an average value of 2,20 particles/g, was higher than that found in water and sediment. This indicates that microplastics accumulate within the clam's body. This differs from the study by Sari et al. (2021), which reported that the abundance of microplastic particles found in the lokan clam on Bengkalis Island was 13,199 particles/g. Bengkalis Island is a coastal area with a high population density and an intensive port, fishing, and maritime transportation activities, which have the potential to generate and accumulate large amounts of plastic waste.

The low abundance of microplastics in the water is thought to be influenced by differences in environmental characteristics and levels of human activity. Sinaboi Beach has relatively low levels of human activity. It is dominated by a mangrove ecosystem that acts as a natural trap for particles, including microplastics, which become trapped in sediment and mangrove roots. Differences in current patterns, tides, and water dynamics also contribute to higher microplastic accumulation compared to the waters off Sinaboi Beach, which tend to be more sheltered.

Differences in Microplastic Abundance in Water, Sediment, and the Lokan Clam (*G. erosa*) at Different Locations

Figure 6 shows differences in microplastic abundance in water, sediment, and the lokan clam across 10 sampling points. The results of these observations show that the highest microplastic abundance was found in lokan clam (2.20 particles/g), followed by sediment (1.74 particles/g) and water (0.45 particles/L).

Based on the Kruskal-Wallis nonparametric test, the abundance of microplastics in water, sediment, and whelks showed significant differences (p-value = 0.001 < 0.05). Laila et al. (2020) state that if the p-value is < 0.05, the mean abundances can be considered different. Thus, the abundance of microplastics in the lokan clam differs significantly from that in water and sediment. This pattern indicates that benthic organisms, particularly the lokan clam, act as microplastic absorbers from their surrounding environment. The high levels of microplastics found in lokan clam are closely related to their natural filter-feeding behavior, which involves filtering particles suspended in water and surface mud. This filtration process removes microplastics, small particles that accumulate in shellfish tissues (Yona et al., 2021).

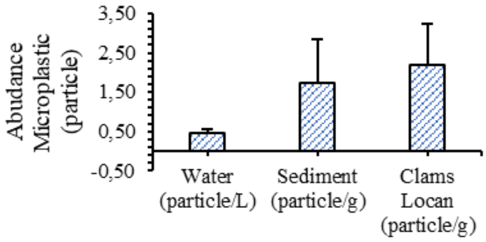

Figure 6. Differences in Microplastic Abundance in Water, Sediment, and *G. erosa* by Sampling Site

Relationship between Microplastic Abundance in Water, Sediment, and the *G. erosa*

The results of the linear regression analysis of microplastic abundance in water and sediment, indicating a positive correlation, are shown in Figure 7. Based on the analysis, the coefficient of determination R^2 was 0,459 and the correlation coefficient r was 0.677, with the regression equation y = -1,720 + 7.632x

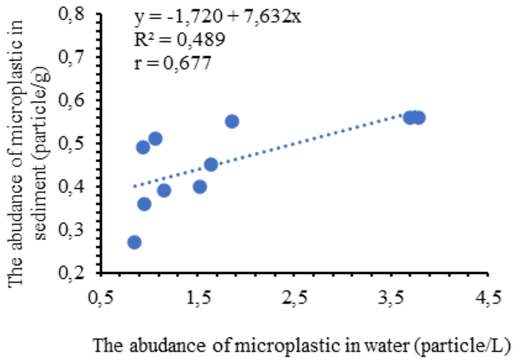

Figure 7. The Relationship between Microplastic Abundance in Water and Microplastic Abundance in Sediment

The coefficient of determination, R^2 = 0,459, indicates that the microplastic abundance variable in water can explain 45,9% of the variation in sediment microplastic abundance. Meanwhile, the remaining 54,1% is influenced by factors beyond the analyzed variables, such as water currents, sediment characteristics (grain size and organic matter content), anthropogenic activities in the surrounding aquatic environment, and the physical and chemical processes occurring there.

A correlation coefficient of 0,677 indicates that the relationship between the two variables falls into the moderate-to-fairly strong category, meaning that as microplastic abundance in the water increases, microplastic abundance in the sediment tends to increase as well. This relationship can be explained by the transport and deposition mechanisms of microplastic particles from the water column to the bottom of the water. This is influenced by the deposition and settling of microplastic particles into the sediment, which is affected by physical factors such as currents and gravitational forces, as well as the characteristics of the microplastic particles themselves, such as size and density (Zhang et al., 2023).

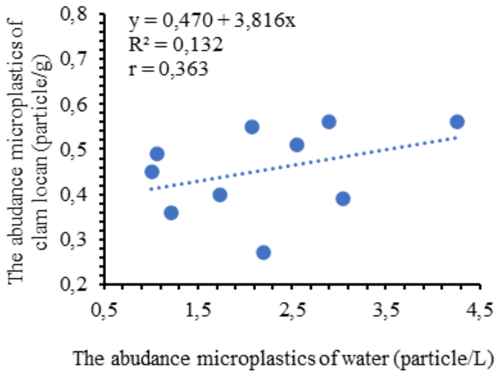

Figure 8. The Relationship between Microplastic Abundance in Water and Microplastic Abundance in *G. erosa*

The results of the linear regression analysis of microplastic abundance in water and in the lokan clam, which indicate a positive correlation, are shown in Figure 8. The coefficient of determination was R^2 = 0,132 and r = 0,363, with the regression equation y = 0,470 + 3,816.

The coefficient of determination, R^2 = 0,132, indicates that 13,2% of the variation in the abundance of the lokan clam can be explained by microplastic abundance in the water. In comparison, 86,8% is influenced by other factors not included in the regression model, such as sediment characteristics, feeding habits (filter feeding), clam size and age, and accumulation processes.

The correlation coefficient of r = 0,363 indicates a positive but weak relationship between microplastic abundance in the water and in the lokan clams. This positive relationship suggests that an increase in microplastics in the water column tends to be followed by an increase in microplastics in the lokan clams. However, the relationship is not particularly strong. Lokan clam acquire microplastic particles through water filtration during feeding and respiration. This finding aligns with the work of Li et al. (2021), who reported that bivalves have a high potential to accumulate microplastics due to their sedentary lifestyle and feeding mechanisms that rely on filtering suspended particles.

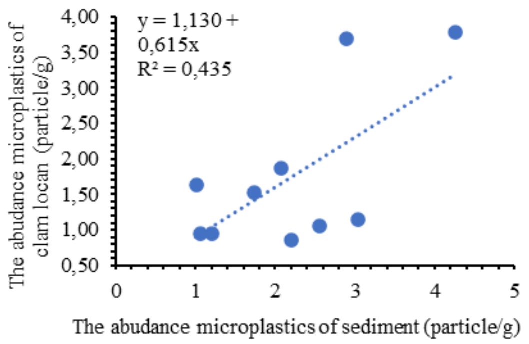

Figure 9. The Relationship between Microplastic Abundance in Sediment and Microplastic Abundance in the Lokan clam (*G. erosa*)

The results of the linear regression analysis between microplastic abundance in sediment and in lokan clam indicate a positive relationship, with $R^2 = 0,435$ and r = 0,659. The regression equation obtained is y = 1,130 + 1,615x, indicating that an increase in sediment microplastic abundance is associated with an increase in lokan clam microplastic abundance.

The coefficient of determination R^2 = 0,435 indicates that 43,5% of the variation in microplastic abundance in lokan clam can be explained by sediment microplastic abundance. In comparison, the remaining 56,5% is influenced by other factors such as clam behavior, individual size and age, habitat conditions, and aquatic environmental dynamics.

The correlation coefficient r = 0,659 indicates a moderate relationship between microplastic abundance in sediment and in the lokan clam. This positive relationship suggests that as microplastic levels in sediment increase, so does the accumulation of microplastics within the lokan clam's body. Sediment plays a more dominant role in microplastic accumulation in the lokan clam. The lokan clam is an organism that lives and is active on the seabed, so it interacts more intensely with sediment than with the water column. Several studies also suggest that microplastics tend to accumulate more in sediment due to sedimentation and biofouling (Wang et al., 2021).

4. CONCLUSION

Based on the study, it was concluded that the microplastics found in the waters off Sinaboi Beach consisted of fibers, fragments, films, and foam. The average microplastic abundance in the lokan clam was the highest at 2,20 particles/g, followed by sediment at 1,74 particles/g and water at 0,45 particles/L. The differences in microplastic abundance in water, sediment, and the lokan clam showed significant differences ($p < 0,05$). Microplastic abundance in sediment and in the lokan clam showed a stronger correlation, as clams are filter-feeding organisms that accumulate microplastics from the sediment

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