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Abundance of Microplastics in Water and Sediment in Coastal Waters of Tanah Merah Village, Meranti Islands Regency

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ABSTRACT

This study aims to analyze the types and abundance of microplastics in water and sediment between research stations and to examine differences in microplastic abundance across sediment depths in the coastal waters of Tanah Merah Village, Meranti Islands Regency. Samples were taken from three different locations: residential areas, fishing ports, and mangrove areas. The number of water and sediment samples from the three research stations was 27. Water quality parameters, including temperature, salinity, pH, and current velocity, were measured to assess the condition of the aquatic environment. The results showed that four types of microplastics were found, namely fragments, fibers, films, and pellets. The abundance of microplastics in seawater had an average value of 0.86 particles/L, with fragments being the most dominant type. Meanwhile, the abundance of microplastics in sediment had an average value of 1084.33 particles/kg of sediment, with fibers dominating. Based on sediment depth, the highest microplastic abundance was observed at station three in the 0-10 cm layer, with an average of 1010 particles/kg of sediment. The abundance of microplastics in water and sediment shows a significant difference. This is because there is a significant relationship between the abundance of microplastics in water and sediment.

Keywords: Microplastics, Seawater, Sediment**,** Abundance, Red Soil

1. INTRODUCTION

Tanah Merah Village is a village in Rangsang Pesisir District, Meranti Islands Regency. Rangsang Island lies east of the Meranti Islands and faces the Strait of Malacca. Activities in the Strait of Malacca are suspected to contribute to the entry of microplastics into the waters of Tanah Merah Village. Waste in the ocean will seriously disrupt the lives of marine life and the communities living in the area (Akbar & Maghfira, 2023). Plastic is found on the coastline, floating on the sea surface, floating in the water column, and as waste that inhabits the ocean floor. This plastic will degrade over time due to mechanical damage, resulting in smaller pieces called microplastics (Alpiansyah et al., 2021).

The high level of plastic pollution in the ocean is one of the pollutants that can negatively impact not only the environment but also the biota within in, which, in turn, can harm humans (Nufus & Zuriat, 2020). The direct impact of plastic pollution in the ocean is the large number of marine organisms that die after ingesting it. Plastic waste accidentally ingested by marine organisms is certainly very dangerous, as contamination of their organs can cause blockages, complications, and even death of organisms in the ocean (Najmi et al., 2022).

The higher concentration of microplastics in sediment compared to on the water surface can be influenced by gravity and the plastic's higher density relative to water, so that plastic that enters the water sinks and accumulates in the sediment (Ambarsari & Aggiani, 2022). The abundance of anthropogenic activity and its geographic location, directly facing the Strait of Malacca, make Tanah Village highly vulnerable to microplastic accumulation. Therefore, identifying microplastics in this area is crucial for determining appropriate mitigation measures to maintain the sustainability of the marine ecosystem and public health.

2. RESEARCH METHOD

Time and Place

This research was conducted in December 2024 in the coastal waters of Tanah Merah Village, Meranti Islands Regency (Figure 1). Analysis of microplastic types and abundance was conducted at the Marine Chemistry Laboratory, Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, Universitas Riau.

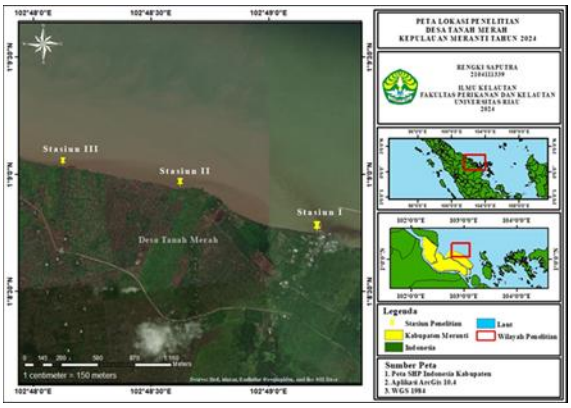


Figure 1. Research Location

Method

The research location was determined using a purposive sampling technique. Determining sampling points using a purposive sampling technique enables the collection of diverse microplastic species in a single sampling session (Ayuingtyas et al., 2019). The sampling locations were divided into three stations: residential areas (station I), fishing ports (station II), and mangrove areas (station III).

Procedures

Measurement of Water Quality Parameters

Analysis of Microplastics in Seawater

Identification of microplastic types in seawater was performed in the laboratory using the method described by Viršek et al. (2016). Microplastic abundance was calculated based on the number of particles in each sample divided by the volume of water sample taken (100 ml), referring to NOAA (2013), with the following formula:

$$C = \frac{n}{v}$$

Information:

- c : Microplastic Abundance (particles/L)
- n : Number of microplastic particles found (particles)
- v : Volume of filtered water (L)

Microplastic Analysis in Sediment

Identification of microplastics in sediment is carried out through several stages: drying, density separation, and visual sorting (Hidalgo-Ruz et al., 2012). The abundance of microplastics in sediment is calculated by dividing the number of microplastic particles found by the mass of the sediment sample (100 g), then converting to particles/kg of dry sediment (Qiu et al., 2015). The calculation of microplastic abundance refers to the formula of Pradiptaadi et al. (2022).

$$c = \frac{n}{m}$$

Information :

- c : Microplastic Abundance (particles/ kg)
- n : Number of microplastic particles (particles)
- m : Dry sediment weight (kg)

Data Analysis

The data obtained from the research were analyzed statistically, presented in tables, figures, and graphs, and discussed descriptively with reference to the literature. Data processing was performed using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS). Analysis of differences in microplastic abundance in seawater and sediment at the research location used a one-way ANOVA test. Meanwhile, to determine differences in microplastic abundance based on depth, an Independent T-test was used. The relationship between microplastic abundance in seawater and sediment was studied using simple linear regression.

3. RESULT AND DISCUSSION

Overview of the Research Location

Meranti Islands Regency consists of three main islands: Merbau, Rangsang, and Tebing Tinggi. Coastal areas in the transition zone between land and sea are vulnerable to the accumulation of waste, especially plastic. The increase in plastic waste in marine ecosystems has become one of the most serious pollution issues today (Aulia et al., 2023). In this region, six coastal villages are potentially affected by plastic pollution: Tanjung Kedabu, Telesung, Bungur, Sonde, Tanah Merah, and Kedaburapat. Tanah Merah Village was chosen as the research location because it has significant coastal activity pressure. This village is located in the Rangsang Pesisir District with an area of ± 9 km² at coordinates 1°09'00.9" South Latitude and 102°47'27.9" East Longitude. The research location is classified as having limited accessibility because it is a coastal area with limited population density. Residents generally earn their living as fishermen and coastal farmers, so their daily activities are highly dependent on aquatic resources. Fishing operations, the use of fishing gear, and the disposal of waste from residential areas and vessels can introduce microplastics into the aquatic environment. Measurements of oceanographic parameters in the coastal waters of Tanah Village are shown in Table 1.

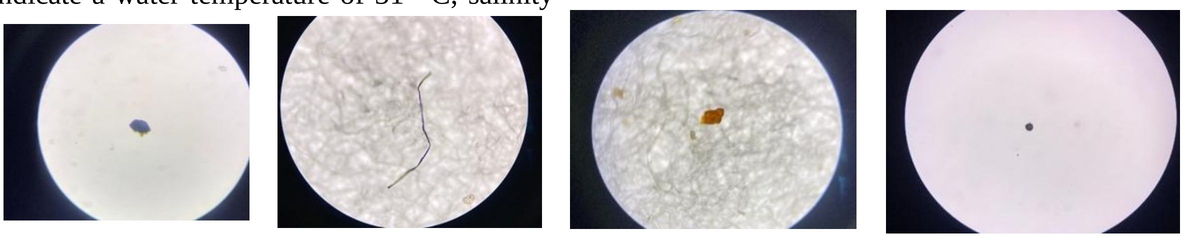
Table 1. Oceanographic Parameters of the Coastal Waters of Tanah Merah Village

No	Parameter	Station 1	Station 2	Station 3	Average
1.	Temperature (^{0} C)	31	31	31	31
2.	Salinity (ppt)	25	23	21	23
3.	Degree of Acidity (pH)	7.22	7.20	7.10	7.17
4.	Current velocity (m/s)	0.03	0.03	0.03	0.03

These parameters were measured because they can affect the distribution of abundance and the degradation process of microplastics, as well as to determine whether the environmental conditions of the Tanah Merah Village Coastal waters are in good condition. As shown in Table 1, the measured values of oceanographic parameters between stations differ little. Based on the data in Table 1, the oceanographic parameter values at the research location indicate a water temperature of 31 ^{0} C, salinity between 21-25 ppt, acidity degree (pH) of 7.10-7.22, and current velocity of 0.03 m/s.

Types of Microplastics Found

Based on the observed results, four types of microplastics were found in seawater and sediment in the coastal waters of Tanah Merah Village, Meranti Islands Regency: fragments, fibers, films, and pellets, as shown in Figure 2.



(a) (b) (c) (d)

Figure 2. Types of Microplastics in Seawater and Sediment Samples; (a) Fragments, (b) Fibers, (c) Films, (d) Pellets

Fragment-type microplastics (Figure a) are fragments of larger plastics, such as bottles, hard packaging, or pipe pieces, that have weathered due to UV exposure and broken down into smaller pieces (Septian, 2018). Fiber-type microplastics (Figure b) generally originate from the degradation of fiber-based materials, such as ship ropes and fishing gear parts that are released into the water. This type is often found in sediments and resembles thin threads or fibers (Browne et al., 2013). Film-type microplastics (Figure c) originate from the degradation of plastic bags and food packaging, which are generally thin, flexible, and transparent. Film fragments have a sheet-like shape with thin, irregular surfaces (Dewi et al., 2015; Yudhantari, 2019). Meanwhile, pellet-type microplastics (Figure d) are primary microplastics that serve as raw materials for the production of plastic products and can enter the aquatic environment through leaks or discharges from industrial activities (Dewi et al., 2015).

Types and abundance of microplastics in seawater

The types and abundances of microplastics at research stations in seawater are shown in Table 2.

Table 2. Types and Abundance of Microplastics in Seawater

Station	Fragment	Fiber	Film	Pellets	Total Abundance (Particles/L)
1	0.56 ± 0.07	0.11 ± 0.04	0.48 ± 0.17	0.00 ± 0.00	1.16 ± 0.21
2	0.38 ± 0.13	0.08 ± 0.02	0.25 ± 0.12	0	0.71 ± 0.27
3	0,29 ± 0,12	0,16 ± 0,04	0,21 ± 0,08	0,05 ± 0,05	0,71 ± 0,27

Based on the observation results, the highest abundance of microplastics at the three research stations was observed in the fragment type, with an average of 0.41 particles/L, followed by the film type at 0.31 particles/L, and then the fiber type at 0.11 particles/L. In contrast, the pellet type had the lowest abundance at 0.01 particles/L. Based on the observation location, Station 1 had the highest abundance of microplastics at 1.16 particles/L, while Station 2 and Station 3 had the same average value of 0.71 particles/L. The results of the One-Way ANOVA test showed a p-value p 0.123 (> 0.05), indicating that the abundance of microplastics between the three stations was not statistically significantly different. This condition indicates that the three stations likely received microplastic input from the same source, such as domestic waste and coastal activities. This is supported by research by Moore et al. (2001), which shows that a single source of microplastics can lead to a uniform distribution in the marine environment.

Types and abundance of microplastics in sediments

The types and abundances of microplastics in sediments from research stations are shown in Table 3.

Table 3. Types and Abundance of Microplastics in Sediments

Station	Fragment	Fiber	Film	Pellets	Total (Particles/kg)
1	80 ±17.32	36.66 ± 37.85	93.33 ± 5.77	16.66 ± 20.81	226.67±56.86
2	106.67±124.23	970 ± 468.93	133.33±111.5	3.33±5.77	1213.3±523.67
3	480 ±301,99	950±199,75	366,67±263,12	16,66 ± 11,54	1813,3±768,46

Based on the observation results, fiber types had the highest abundance at the three research stations, with an average of 652.22 particles/kg of sediment, followed by fragments at 222.22 particles/kg, films at 197.77 particles/kg, and pellets, which had the lowest abundance at 12.22 particles/kg of sediment. Station 3 showed the highest abundance of microplastics at 1,813.33 particles/kg of sediment, followed by Station 2 at 1,213.33 particles/kg, while Station 1 had the lowest abundance at 226.67 particles/kg of sediment.

The results of the One-Way ANOVA analysis showed a p-value of 0.030 (< 0.05), indicating a significant difference in microplastic abundance between stations. Further analysis using the LSD test revealed that the difference in microplastic abundance between Stations 1 and 2 was not significant, while between Stations 1 and 3, it was very different. These differences are likely caused by variations in pollution sources, ocean current patterns, environmental conditions, and human activities around the two stations.

Abundance of Microplastic Types based on Depth

The highest abundance of microplastics was recorded at Station 3 in the 0–10 cm sediment layer with a value of 1,010 particles/kg sediment, while the lowest abundance was found at Station 1 at a depth of 10–20 cm at 96.66 particles/kg sediment. The results of the independent-samples t-test showed a p-value of 0.871 (> 0.05), indicating that the abundance of microplastics at the two depths was not significantly different. These results indicate that the distribution of microplastics in the sediment was relatively even between the 0–10 cm and 10–20 cm layers. This is likely influenced by mechanisms of vertical particle movement, such as bioturbation by benthic organisms or percolation through sediment pores, which can distribute microplastics to deeper layers. Therefore, the depth of the studied sediment was not a major factor in the differences in microplastic concentrations at the study site. Data on the abundance of microplastic types by sediment depth are shown in Table 4.

Table 4. Abundance of Microplastic Types based on Sediment Depth

Station	Depth 0-10 cm	Depth 10-20 cm
1	130 ± 95.39	96.66 ± 63.50
2	466.67 ± 153.08	746.67 ± 370.72
3	1010 ± 653.91	803.33 ± 136.14

Relationship between Microplastic Abundance in Seawater and Sediment

The abundance of microplastics in seawater and sediment is strongly correlated, given the direct interaction between microplastic particles suspended in the water and those accumulated in the sediment. The relationship between microplastic abundance in water and sediment is shown in Figure 3.

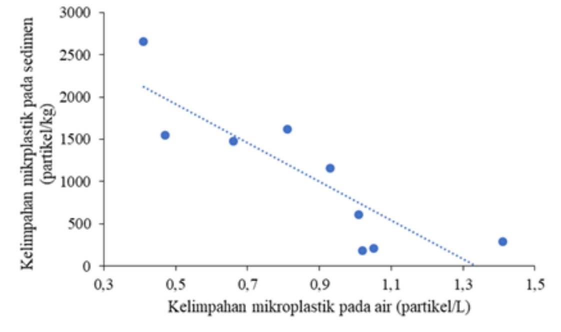


Figure 3. Relationship between Microplastic Abundance in Seawater and Sediment

Based on the results of the simple linear regression test, the value of y = 3066.119 – 2295.376x, the value of the coefficient of determination R^2 = 0.862, and the value of the correlation coefficient r = 0.744.

4. CONCLUSION

Fragments accounted for the majority of microplastics in seawater, while in sediment, fibers predominated. Station 1 showed the highest abundance of microplastics in the water column, while the highest accumulation in sediment was found at Station 3. Differences in microplastic abundance between stations were significant in sediment, but not in seawater. Sediment depth did not significantly affect microplastic distribution. Furthermore, microplastic abundance in seawater showed a negative relationship with microplastic accumulation in sediment at the study site.

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