

Types of mesoplastic waste in the Manggar Beach tourism area, Balikpapan City, East Kalimantan

Muhammad Akbar Rifanka | Irwan Ramadhan Ritonga* | Ristiana Eryati

Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Mulawarman University
Jl. Gunung Tabur No. 1. Kampus Gn. Kelua Samarinda 76123

*E-mail: ritonga_irwan@fpik.unmul.ac.id

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ABSTRACT

Plastic waste poses a significant threat to the global environment, particularly in coastal and marine ecosystems. Among its various forms, mesoplastics, measuring between 5 and 25 mm have attracted considerable attention. This study aims to identify and analyze the types, weights, quantities, compositions, and densities of mesoplastics found along Manggar Beach, a tourist destination in Balikpapan City, East Kalimantan. Sampling was conducted in two periods: April (Period I) and August (Period II) of 2022. A purposive sampling method was applied using a 100-meter transect line divided into 5x5 meter lanes, followed by the placement of 1x1 meter quadrats. In Period I, four types of mesoplastics were identified as film, fiber, fragments, and styrofoam, while only film was detected in Period II. A total of 43 mesoplastic particles (weighing 9.45 grams) were recorded in Period I, compared to just 5 particles (0.15 grams) in Period II. By weight, styrofoam made up the largest proportion (49%) in Period I, whereas film accounted for 100% in Period II. The average mesoplastic density observed in this study was 0.38 particles per square meter.

INTRODUCTION

Plastic waste has emerged as a serious environmental issue worldwide, including in Indonesia. Approximately 60–90% of plastic waste can be found along coastlines, on the surface of water bodies, and on the seafloor (Râpă et al., 2024). According to studies, Indonesia ranks as the second-largest contributor of plastic waste to the ocean, following China, with an estimated 187.2 million tons of plastic entering the sea (Jambeck et al., 2015). Plastic pollution is increasingly difficult to control due to the long degradation time of plastics in the environment. Moreover, the growing human population contributes to an increase in waste generation. In general, plastic waste in the environment is categorized into five types: mega-debris, macro-debris, meso-debris, micro-debris, and nano-debris (Lippiatt et al., 2013). Mesoplastics are plastic particles ranging in size from 5 mm to 25 mm, resulting from the degradation of larger plastic debris (Yona et al., 2020).

One of the areas in Indonesia experiencing plastic waste problems is the Manggar Beach tourism area in Balikpapan City. This beach has attracted a significant number of tourists, ranging from 73,025 to 225,004 visitors between 2019 and 2021 (Silalahi, 2023). Tourists, both local and from other regions, visit the site to enjoy its natural scenery and coastal ambiance. Several supporting facilities are available around the beach, including spacious parking areas, food and beverage vendors, and prayer rooms, all intended to enhance the visitor experience. On the other hand, the high volume of tourist activity may contribute to increased plastic pollution along the beach and in nearby marine waters. In addition, the low awareness among the public and business operators regarding waste disposal has negatively impacted the surrounding

environment, particularly the marine ecosystem (Vianka, 2021). One visible consequence of macro- and mesoplastic pollution is the deterioration of coastal aesthetics and cleanliness (Nurhayati et al., 2023; Rindyani et al., 2023). Furthermore, plastic-contaminated beaches can diminish visitor comfort (Mardiana et al., 2022), potentially prompting tourists to choose alternative destinations, thereby reducing the income of affected coastal communities (Grilli et al., 2022).

In recent years, several investigations on plastic waste have been conducted in coastal ecotourism areas in Balikpapan, such as mesoplastics at Le Grandeur Beach (Nur et al., 2022), macro- and mesoplastics at Lamaru Beach (Nurhayati et al., 2023; Nursari et al., 2023), and microplastics at Seraya Beach, Persatuan Manggar Baru, Mulawarman Manggar, Klandasan Ulu, Monpera, Margasari, and Somber (Maulia, 2023; Wulandari et al., 2021). However, information on mesoplastics specifically in the Manggar Beach ecotourism area remains very limited. This information is essential for informing environmental management policies in coastal ecotourism zones in Balikpapan. Based on this context, this study aims to investigate and analyze the types, weight, quantity, composition, and density of mesoplastics found in the Manggar Beach tourism area, Balikpapan City, East Kalimantan.

METHODOLOGY

Mesoplastic sampling was conducted at the Manggar Beach area, Balikpapan City, East Kalimantan Province, from April (Period I) to August (Period II) 2022. Sample analysis was carried out at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Mulawarman University.

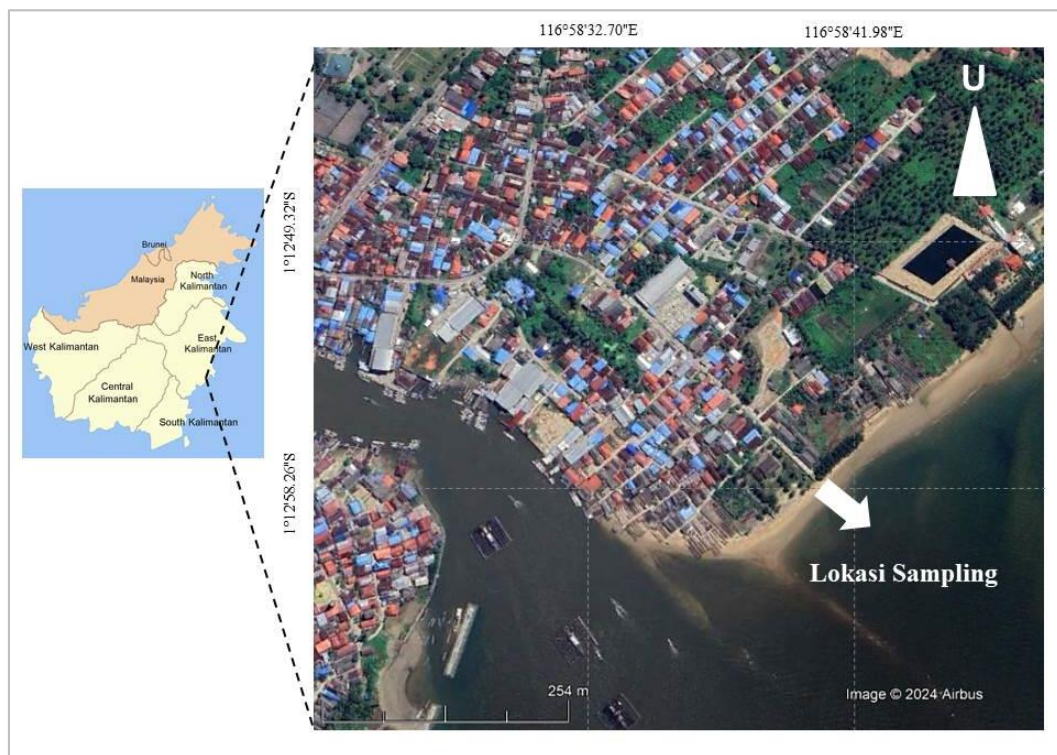


Figure 1. Study location map

Research procedure

A transect line was established over a 100-meter stretch parallel to the shoreline, extending at least 5 meters inland. The 100-meter transect line was divided into five lanes, each separated by 20 meters (Figure 2A). Within each lane, a sub-transect measuring 5×5 meters was designated, and within each sub-transect,

sub-sub transects (quadrat transects) measuring 1×1 meter were created, resulting in 25 quadrats per sub-transect. Each quadrat was numbered from 1 to 25. Mesoplastic samples were then collected using a random sampling method, selecting 5 out of the 25 quadrats in each sub-transect using a randomizer (Urbaniak & Plous, 2013) (Figure 2B).

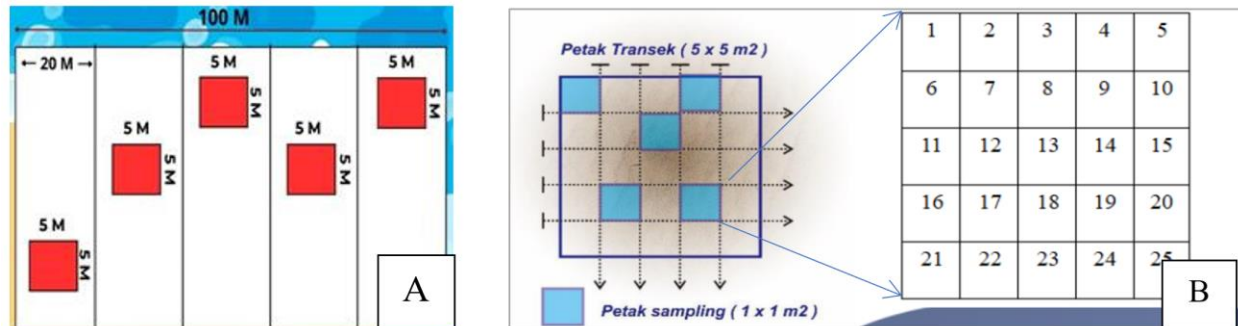


Figure 2. Transect Observation Scheme (A), Sub-Transect Scheme at the Beach (B) (Prajanti et al., 2020)

Data analysis

The waste density in this study was calculated based on the number of waste items per type per square meter at each sampling station (items/m²), following the method by Prajanti et al. (2020):

$$\text{Density} = \frac{\text{Number of waste items per type}}{\text{Length (m)} \times \text{Width (m)}}$$

All data obtained in this study were processed and analyzed using Microsoft Excel for Windows. The results, including all figures and tables, are presented and described descriptively.

RESULT AND DISCUSSION

Types, quantity, and weight of mesoplastics

Based on shape categories, three types of mesoplastics were identified during Period I: film, styrofoam, and fragments. In Period II, only one type—film—was found. Overall, the total number of mesoplastic particles collected during both sampling periods was 48. The presence of plastic waste at the study site is likely a result of the degradation of marine litter such as food packaging, plastic bags, sacks, and cigarette waste. These materials are believed to originate from tourist activities, particularly from improper disposal of waste. According to Thushari & Senevirathna (2020), a high concentration of beach litter often results from human activities, both by local residents and visiting tourists. Plastic waste, which served as the main source of mesoplastics in this study, degrades into smaller fragments in the coastal environment—consistent with the findings of Zhang et al. (2017).

In terms of quantity, the number of mesoplastic particles found in Period II was significantly lower—approximately eight times less—than that in Period I. This decrease may be associated with the designated use of the Manggar Beach area, which is known as a prominent tourism destination in Balikpapan City. Efforts to attract more visitors include maintaining the cleanliness of the beach. Consequently, beach cleaning is routinely conducted by maintenance staff on a monthly basis to preserve the aesthetic appeal of the area. In addition, hydro-oceanographic factors such as currents, waves, tides, and sea level fluctuations are also believed to influence the reduced presence of mesoplastics in Period II. This assumption is supported by previous studies by Wulandari et al. (2022) and Hamid et al. (2018), which indicate that ocean

currents, wave action, tidal patterns, wind direction, and seasonal variation all contribute to the distribution of plastic debris in coastal and marine environments.

The most abundant mesoplastic category found in Period I was fiber, with a total of 18 particles (Figure 4A). Fiber waste typically originates from fishing activities, such as fishing lines and nets. The second most common type was styrofoam, with 17 particles. According to Astuti et al. (2021), styrofoam is widely used in food and beverage packaging. The remaining types of mesoplastics found included film and fragments, with four particles each. As described by Andrady (2011), fragment-type plastic debris results from the breakdown of larger, hard, and rigid plastic materials. In Period II, only film-type mesoplastics were found, with a total of five particles (Figure 4B). Film-type waste is characterized by its low density and typically originates from the degradation of plastic packaging (Kingfisher, 2011, in Sari Dewi et al., 2015). According to Yona et al. (2020), film-type mesoplastics may continue to increase in coastal areas due to the public's continued reliance on plastic products in daily life.

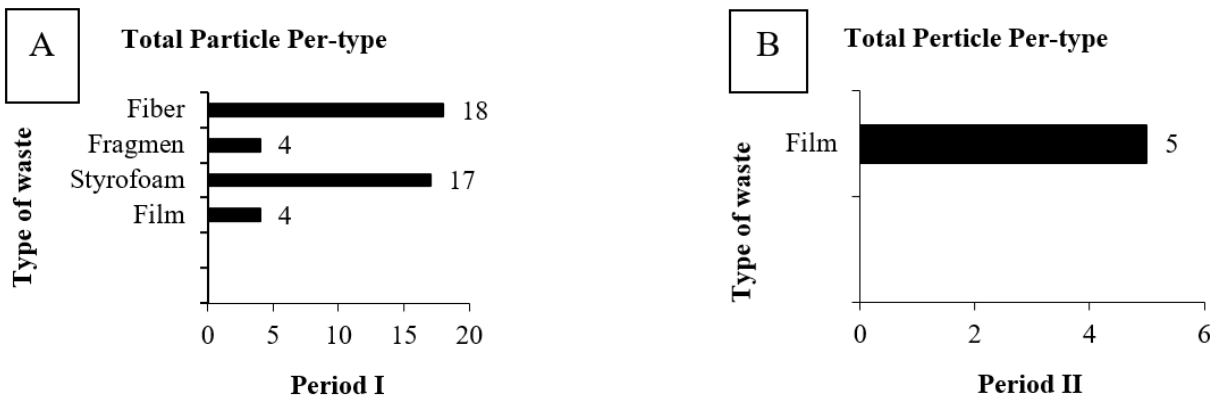


Figure 4. Categories and quantities of mesoplastics in Period I (A) and Period II (B)

Based on the total quantity of mesoplastics, the total weight of debris recorded in Period I was 9.45 grams, while in Period II it was only 0.15 grams. The heaviest type of mesoplastic in Period I was styrofoam, weighing 4.63 grams, followed by fiber at 4.27 grams. Other types recorded in Period I included fragments at 0.54 grams and film at 0.01 grams. In Period II, only film-type mesoplastics were found, with a weight of 0.15 grams (Table 1). Overall, the total weight of mesoplastics in Period I was considerably higher than in Period II.

The total amount and weight of mesoplastics in this study were significantly lower compared to findings by Djaguna et al. (2019), who recorded 281 plastic particles and a total macro- and mesoplastic debris weight of 1,433.38 grams at Tongkaina and Talawaan Bajo beaches.

Table 1. Mesoplastic mass

No.	Type of Mesoplastic	Mesoplastic Weight (g/m ²)	
		Period I	Period II
1	Film	0.01	0.15
2	Styrofoam	4.63	—
3	Fragment	0.54	—
4	Fiber	4.27	—
	Total Weight (g)	9.45	0.15
	Average Weight (g)	2.36	0.01

No.	Type of Mesoplastic	Mesoplastic Weight (g/m ²)	
	Transect Area (m ²)	25	25
	Mass (g/m ²)	0.38	0.01

“-” indicates that no mesoplastics were found.

As shown in Table 1, mesoplastic mass in Period I was 0.38 g/m², while in Period II it was only 0.01 g/m². In general, Period I exhibited a higher mass than Period II. This difference is suspected to be due to irresponsible waste disposal by visiting tourists, which may have increased the amount and weight of mesoplastics. Additionally, fishing activities near the beach and river—especially those close to residential areas—may also contribute to the increased presence of mesoplastic debris.

The analysis revealed that film-type mesoplastics were present in both sampling periods, with a cumulative mass of 0.16 g/m². This finding suggests that film is one of the most significant contributors to plastic debris by weight. The high mass of film-type debris in this study is likely due to the cumulative effects of plastic waste from human activity—including local residents, tourists, and fisheries—combined with oceanographic dynamics such as tides, currents, and wave action. This aligns with Damayanti et al. (2022), who stated that plastic waste is easily transported by waves due to its generally low weight.

Mesoplastic composition

The highest mesoplastic composition in the Manggar Beach tourism area during Period I was styrofoam (49%), consisting of foam and polystyrene fragments, followed by fiber (45%), primarily in the form of cigarette filters. The lowest composition was fragments (6%), which included items such as LPG (Liquefied Petroleum Gas) or kerosene bottle caps, adhesive plastics, toy fragments, and other plastic materials (Figure 3A). In Period II, only film-type debris was found, comprising 100% of the mesoplastic composition (Figure 3B). In general, the composition of mesoplastics is suspected to originate from the activities of visitors and local residents living near the beach area. According to Erikson et al. (2014) and Thushari & Senevirathna (2020), plastic is an inorganic material that tends to float easily in aquatic environments, exhibits long-term durability, and is one of the most widely distributed pollutants across the world's oceans.

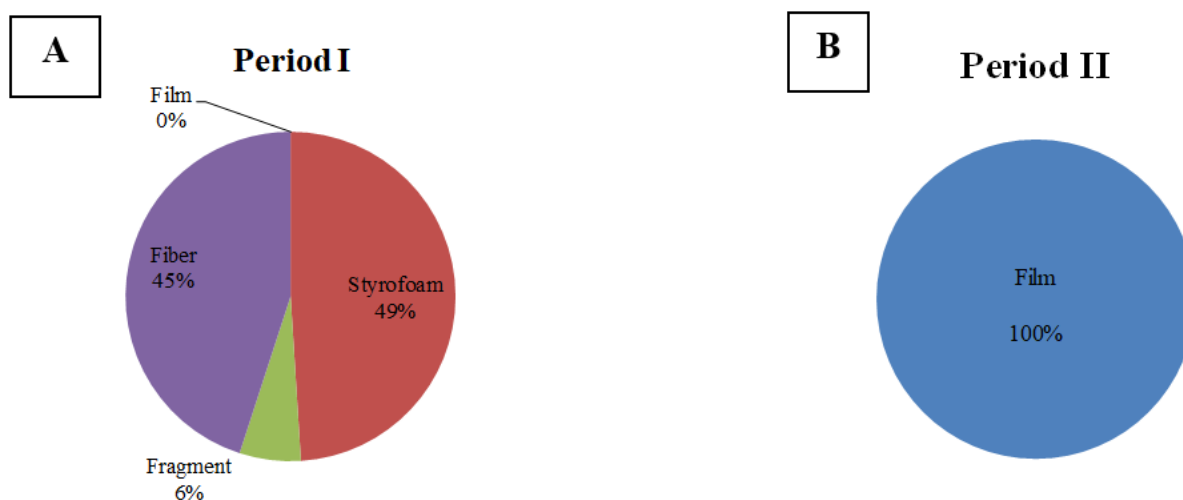


Figure 3. Composition of mesoplastics in Period I (A) and Period II (B)

Mesoplastic density

In Period I, the dominant mesoplastic type by density was fiber waste (0.72 particles/m²), followed by styrofoam (0.68 particles/m²), film (0.16 particles/m²), and fragments (0.16 particles/m²). In Period II, only film-type mesoplastics were found, with a density of 0.20 particles/m². The total mesoplastic density in Periods I and II was 1.72 particles/m² and 0.20 particles/m², respectively. Overall, the cumulative mesoplastic density across both periods was 1.92 particles/m² (Table 2).

Table 2. Mesoplastic density

No.	Type of Mesoplastic	Mesoplastic Density (particles/m ²)	
		Period I	Period II
1	Film	0.16	0.20
2	Styrofoam	0.68	–
3	Fragment	0.16	–
4	Fiber	0.72	–
	Total	1.72	0.20
	Total Density	1.92 particles/m ²	
	Transect Area	25 m ²	
	Average Density	0.38 particles/m ²	

“–” indicates that no mesoplastics were found.

The higher mesoplastic density observed in Period I may be attributed to several factors, such as direct inputs of mesoplastic debris as well as local oceanographic conditions—including currents, waves, tides, and beach slope. For instance, secondary data (<http://www.aviso.altimetry.fr/>) showed that the current velocity one day before sampling ranged from 0.341 to 0.521 m/s. On the sampling day itself, current velocities ranged from 0.339 to 0.408 m/s. Generally, these values fall within the category of moderate current velocity. These findings are consistent with those of Damayanti et al. (2022), who reported that oceanographic factors such as currents and tides significantly influence plastic debris distribution along coastlines. Furthermore, seasonal variation also plays a role in the distribution of plastic waste (Wulandari et al., 2022).

CONCLUSION

1. Four types of mesoplastics were identified in the Manggar Beach tourism area during Period I: film, fiber, fragment, and styrofoam. In contrast, only film-type mesoplastics were found in Period II.
2. The total number of mesoplastic particles recorded in the Manggar Beach area was 43 particles in Period I, with a total weight of 9.45 grams. In Period II, 5 particles were found with a total weight of 0.15 grams.
3. The dominant mesoplastic composition by weight in Period I was styrofoam (49%) and fragments (6%), while in Period II, only film-type mesoplastics were recorded (100%).
4. The average mesoplastic density recorded in this study was 0.38 particles/m².

REFERENCES

- Andrady, A. L. (2011). Microplastics in the Marine Environment. *Marine Pollution Bulletin*, 62(8), 1596–1605. <https://doi.org/10.1016/j.marpolbul.2011.05.030>

- Astuti, S. P., Candri, D. A., Ahyadi, H., & Sunarwidhi, E. P. (2021). Pemanfaatan Sampah Plastik Dan Styrofoam Sebagai Media Hidroponik Bagi Masyarakat Pesisir Ampenan. *Abdi Insani*, 8(3), 311–318. <https://doi.org/10.29303/abdiinsani.v8i3.441>
- Damayanti, A. A., Larasati, C. E., Amir, S., Setyono, B. D. H., & Lestari, D. P. (2022). Karakteristik Meso-Size Marine Debris di Kawasan Wisata Pesisir Barat Kota Mataram. *Jurnal Sains Teknologi & Lingkungan*, 8(1), 38–47. <https://doi.org/10.29303/jstl.v8i1.314>
- Dewi, I. S., Budiarsa, A. A., & Ritonga, I. R. (2015). Distribusi Mikroplastik pada Sedimen di Muara Badak, Kabupaten Kutai Kartanegara. *Depik*, 4(3), 121–131.
- Djaguna, A., Pelle, W. E., Schadu, J. N., Manengkey, H. W., Rumampuk, N. D., & Ngangi, E. L. A. (2019). Identifikasi Sampah Laut Di Pantai Tongkaina Dan Talawaan Bajo. *Jurnal Pesisir Dan Laut Tropis*, 7(3), 174. <https://doi.org/10.35800/jplt.7.3.2019.24432>
- Grilli, G., Andrews, B., Ferrini, S., & Luisetti, T. (2022). Could a Mix of Short- and Long-Term Policies be the Solution to Tackle Marine Litter? Insights From a Choice Experiment in England and Ireland. *Ecological Economics*, 201, 107563. <https://doi.org/10.1016/j.ecolecon.2022.107563>
- Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Entradas de residuos plásticos desde la tierra al océano. *Ciencia*, 347(6223), 768–771.
- Lippiatt, S., Opfer, S., & Arthur, C. (2013). Marine Debris Monitoring and Assessment : Recommendations for Monitoring Debris Trends in the Marine Environment. *NOAA Technical Memorandum, NOS-OR&R-46*, 88.
- Mardiana, B. W., Sari, D. S., Hemamalini, H., Yasmin, L., Adistira, L. G. A. K. D., Sari, L. P., Ludyasari, S. T., Sumbawati, Y., & Setiawan, H. (2022). Aksi Bersih Pantai Dalam Meningkatkan Lingkungan Bersih Di Pantai Seger Kuta Lombok. *Jurnal Interaktif: Warta Pengabdian Pendidikan*, 2(1), 1–5. <https://doi.org/10.29303/interaktif.v2i1.48>
- Maulia, R. (2023). *Analisis Kelimpahan Mikroplastik pada Perairan Pantai Seraya, Kota Balikpapan, Propinsi Kalimantan Timur*. Skripsi. Universitas Mulawarman.
- Nur, D. I., Ghitarina, G., & Mustakim, M. (2022). Analisis Kepadatan Mesoplastik Di Pantai Le Grandeur Kota Balikpapan Kalimantan Timur. *Maiyah*, 1(1), 49. <https://doi.org/10.20884/1.maiyah.2022.1.1.6646>
- Nurhayati, F., Eryati, R., & Ritonga, I. R. (2023). Identifikasi dan Perbandingan Komposisi Kepadatan Mesodebris pada Pantai Wisata. *BIOEDUSAINS: Jurnal Pendidikan Biologi Dan Sains*, 6(1), 273–283.
- Nursari, A., Ritonga, I. R., & Eryati, R. (2023). Karakteristik Sampah Makroplastik di Pantai Wisata Lamaru Kota Balikpapan. *Jurnal Sains Teknologi & Lingkungan*, 9(2), 342–351. <https://doi.org/10.29303/jstl.v9i2.431>
- Prajanti, A., Berlianto, M., Simamora, R. L., Imansari, M. B., & Sari, N. (2020). Pedoman Pemantauan Sampah Laut. In *Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia*. https://pertalindo.or.id/download/file/Pedoman_Pemantauan_Sampah_Laut.pdf.
- Răpă, M., Cârstea, E. M., Șăulean, A. A., Popa, C. L., Matei, E., Predescu, A. M., Predescu, C., Donțu, S. I., & Dincă, A. G. (2024). An Overview of the Current Trends in Marine Plastic Litter Management for a Sustainable Development. *Recycling*, 9(2), 1–30. <https://doi.org/10.3390/recycling9020030>
- Rindyani, A., Eryati, R., & Ritonga, I. R. (2023). Identifikasi Jenis dan Kepadatan Sampah Laut di Pantai Mutiara Indah dan Pelangi Kabupaten Kutai Kartanegara. *Jurnal Perikanan*, 13(4), 1043–1055.
- Shahul Hamid, F., Bhatti, M. S., Anuar, N., Anuar, N., Mohan, P., & Periathamby, A. (2018). Worldwide Distribution and Abundance of Microplastic: How Dire is the Situation? *Waste Management and*

- Research*, 36(10), 873–897. <https://doi.org/10.1177/0734242x18785730>
- Silalahi, I. P. (2023). Strategi Meningkatkan Daya Tarik Wisata pada Pantai Manggar Segara Sari di kota Balikpapan. *Administrasi Bisnis FISIPOL UNMUL*, 11(2), 99–103.
- Thushari, G. G. N., & Senevirathna, J. D. M. (2020). Plastic Pollution in the Marine Environment. *Heliyon*, 6(8), 1–16. <https://doi.org/10.1016/j.heliyon.2020.e04709>
- Urbaniak, G. C., & Plous, S. (2013). *Research Randomizer version 4.0*.
- Vianka, M. I. (2021). Penegakan Hukum Lingkungan Atas Pembuangan Limbah Plastik Di Indonesia. *Morality: Jurnal Ilmu Hukum*, 7(2), 245. <https://doi.org/10.52947/morality.v7i2.221>
- Wulandari, M., Prasaningtyas, A., Ma'arij Harfadli, M., & Handayani, A. M. (2021). Distribution of Microplastic at Sediment on Balikpapan Coastal Area. *Jurnal Presipitasi : Media Komunikasi Dan Pengembangan Teknik Lingkungan*, 18(1), 153–160. <https://doi.org/10.14710/presipitasi.v18i1.153-160>
- Wulandari, S. Y., Radjasa, O. K., Yulianto, B., & Munandar, B. (2022). Pengaruh Musim dan Pasang Surut Terhadap Konsentrasi Mikroplastik di Perairan Delta Sungai Wulan, Kabupaten Demak. *Buletin Oseanografi Marina*, 11(2), 215–220. <https://doi.org/10.14710/buloma.v11i2.46329>
- Yona, D., Di Prikah, F. A., & As'adi, M. A. (2020). Identifikasi dan Perbandingan Kelimpahan Sampah Plastik Berdasarkan Ukuran pada Sedimen di Beberapa Pantai Kabupaten Pasuruan, Jawa Timur. *Jurnal Ilmu Lingkungan*, 18(2), 375–383. <https://doi.org/10.14710/jil.18.2.375-383>
- Zhang, W., Zhang, S., Wang, J., Wang, Y., Mu, J., Wang, P., Lin, X., & Ma, D. (2017). Microplastic Pollution in the Surface Waters of the Bohai Sea, China. *Environmental Pollution*, 231, 541–548. <https://doi.org/10.1016/j.envpol.2017.08.058>