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Abundance and Characteristics of Microplastics in Surface Waters of Banten Bay, Serang, Indonesia

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ABSTRACT

Microplastics are plastic particles measuring less than 5mm in size. Microplastics that infiltrate the environment accumulate in aquatic systems and are challenging to eradicate due to their persistent properties. The activity and source of other pollutants significantly influence the prevalence of microplastics in aquatic environment. This study aimed to determine the frequency and classification of microplastics in Banten Bay's waters. Sampling was performed at five sites selected to represent diverse activities in the surrounding area of the waters. The concentration of microplastic particles observed at five sampling sites in Banten Bay ranged from 0.12 to 1.029 particles/L. The discovered microplastics comprised fragments, fibers, and films. The most commonly identified types of microplastics were fragments (52.645%) and fibers (41.79%), followed by films (5.56%). The prevalence of these two categories is mostly affected by domestic wastes and human activities. Microplastics measuring between 500 and 1000µm are commonly identified at the five specified monitoring locations in the Banten Bay area. The primary microplastics discovered were blue, black and transparent in color. Polypropylene (38%), propylene (25%), and polyethylene (22%) are the predominant materials across the five sampling sites. These findings highlight the widespread presence of microplastics in Banten Bay and emphasize the need for improved waste management and pollution control to mitigate further contamination. The dominance of fragments and fibers suggests ongoing degradation of larger plastics and direct input from domestic sources. Regular monitoring and public awareness are crucial in managing microplastic pollution in coastal waters. Future research should focus on the ecological impact of these particles on marine organisms and the food chain.

INTRODUCTION

Plastic is an essential material extensively utilized by the global community for diverse domestic and industrial purposes due to its lightweight, robustness, and malleability **(Aliabad *et al.*, 2019; Rios Mendoza & Balcer 2019; Firdaus *et al.*, 2020)**. The over use of plastic, coupled with inadequate post-consumption handling, leads to a surge in its prevalence and results in environmental pollution, particularly in aquatic habitats. According to data from the **Ministry of Environment and Forestry's (KLHK) (2024)** in National Waste Management Information System (SIPSN), only 65.71% of the total waste generated in Indonesia was properly managed, while the remaining 34.29% was inadequately handled. Plastic is resistant to degradation and has the ability to absorb hydrophobic substances that are long-lasting and harmful in aquatic environments **(Rios Mendoza & Balcer, 2019)**.

The synthetic organic polymers that make up plastic are capable of physical, mechanical and biological fragmentation into small particles. Furthermore, **Anderson *et al.* (2017)** demonstrated that the presence of industrial effluent and plastic debris in aquatic ecosystems leads to the extensive distribution of small plastic particles. According to **Cordova and Hernawan (2018)**, small plastics or microplastics are categorized into four groups based on their size: those that are <300µm, 300-500µm, 500-1000µm, and >1000µm. Industrial wastewater is the primary origin of microplastics, which are generated during the production of beauty/cosmetic chemicals, cleaners, plastic containers, scrubbers, and pellets in various products **(Anderson *et al.*, 2017; Alam *et al.*, 2019)**. Another form of plastic pollution in water is the fragmentation of plastic trash. This accumulation amounts to 4.80-12.70 million tonnes annually, with Indonesia contributing approximately 1.29 tonnes per year **(Jambeck *et al.*, 2015; Alam *et al.*, 2019; Aliabad *et al.*, 2019)**. Microplastics are categorized into fragments, fibers, films, foam, and granules based on their morphology **(Widianarko & Hantoro 2018; Yona *et al.*, 2020)**. Microplastics can be categorized based on the specific polymer they are made of, including polyvinylchloride (PVC), polyethylene (PE), polystyrene (PS), polypropylene (PP), and polyester (PES) **(Anderson *et al.*, 2017; Aliabad *et al.*, 2019)**.

Microplastics have been detected in various global water bodies, including Canadian waterways **(Anderson *et al.*,, 2017)**, China **(Zhu *et al.*,, 2018)**, and India **(Sarkar *et al.*, 2019)**. Microplastics have been detected in various Indonesian aquatic ecosystems, such as the waters of Sumba, East Nusa Tenggara **(Cordova & Hernawan, 2018),** Ciliwung Estuary Waters **(Cordova *et al.*, 2020)**, Bungus Bay waters **(Islami *et al.*,, 2020)**, National Park Reef waters Karimunjawa **(Muchlissin *et al.*,, 2020),** seagrass waters **(Lestari *et al.*,, 2021)**, and Jakarta Bay waters **(Cordova *et al.*, 2022a)**. Aquatic habitats function as primary repositories for vital resources, such as consumable goods, commercial fishing, aquaculture, and recreational tourism. Banten is a region known for its dense population and diverse community activities. Given its proximity to the coastline, the bay area is prone to microplastic pollution. This vulnerability stems from the substantial influx of domestic and industrial trash emanating from rivers and the several ports situated around the bay **(Setiawan, 2019)**. The Cibanten, Cikamayung, Ciujung Lama, Cikranjung, Cilengkong, Ciujung, and Ciluncing rivers are the primary tributaries that discharge into Banten Bay **(Rustam *et al.*, 2018)**. Furthermore, the rapid expansion of residential areas, industrial activities, and service sectors within the watershed has contributed significantly to the contamination of Banten Bay with microplastics **(Cordova *et al.*, 2022b)**. Banten Bay is characterized by its shallow depth and sedimentary bottom composed of sandy mud, resulting in largely stagnant water. The Banten Bay area is currently undergoing remarkable expansion. Banten Bay is situated at the furthest western tip of the North Coast of Java and falls within the administrative jurisdiction of Serang Regency and City, Banten Province **(Solihuddin *et al.*, 2020)**.

Ongoing research is being conducted to determine the prevalence of microplastics in the aquatic environment, with a particular focus on the Banten Bay. The purpose of gathering this information is to assess the state of the aquatic environment in Indonesia and enhance public awareness in order to formulate strategies and implement measures to mitigate microplastic pollution, thereby minimizing its adverse effects on environmental ecosystems and human health. Therefore, it is imperative to gather data on the presence of microplastics in Banten Bay's surface water environment, including their quantity, shape, color, size, and the types of polymers typically seen. This research aimed to fulfill this objective.

MATERIALS AND METHODS

Study area

Surface water samples for microplastic analysis were collected from five locations in the waters of Banten Bay, Serang City, namely Karangantu, Cengkok, Kemayungan, Pulau Lima, and Pabean. Sampling was conducted monthly during the period from July to September 2022. Banten Province has a geographical position at 05°49'45”-06°02'00”S and 106°03 '00” - 106°16'00” East Longitude and has a fairly strategic location for shipping routes. The five water sampling locations where microplastics were detected are characterized by aquatic conditions influenced by various human activities in the surrounding areas. These activities include marine transportation, aquaculture practices, and residential development. Specifically, Karangantu is located near a fish auction site, a mangrove ecotourism area, and residential zones; Cengkok is adjacent to residential areas; Kemayungan is situated near a traditional fish trap area; the area around Lima Island lies close to a small uninhabited island; and Pabean is surrounded by milkfish aquaculture ponds (Fig. 1).

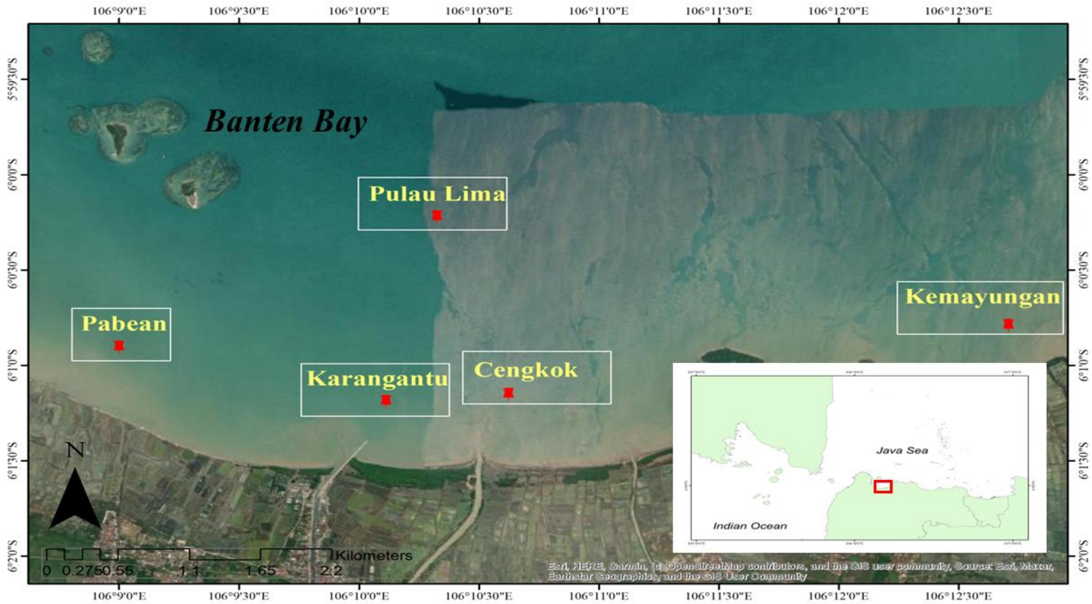

Fig. 1. Location map with five sampling stations in Banten Bay, Serang, Indonesia

Sampling methods

The water sampling approach was conducted according to the **Cordova *et al.* (2022a)** protocol, which involved utilizing a manta net with a 350cm^2 opening and an 80μm mesh size. The sampling was conducted at five designated locations on the ocean surface. The distance between the sampling locations and the shoreline ranges from 2 to 5 kilometers. The manta net was deployed roughly 1 meter from the boat's hull and submerged at a depth of 20–30cm below the sea surface. It was towed at a speed of booth 2 knots for 10 minutes during each sampling session, with the procedure repeated three times. Manta nets are equipped with bilateral wing-like features that ensure stability and buoyancy in aquatic environments. **Yutaka *et al.* (2019)** stated that researchers commonly employ neuston nets and manta nets to effectively capture microplastics present on the surface of the sea, as these nets are capable of filtering substantial volumes of water.

Water samples collected using the manta net were transferred into 500mL aluminum sample bags, with a total volume of approximately 1.5 liters collected per sampling session. The bag is properly tagged and transported to the laboratory for analysis. During the process of collecting water samples in the field, field blanks were employed to detect the presence of microplastic pollution in the field. When collecting samples, it is crucial to consider the wind speed and wave height. For example, sampling was conducted under relatively calm sea conditions to maintain vessel stability at a towing speed of 2 knots. Wind speed was also carefully considered, with sampling performed during periods of moderate wind blowing to reduce surface turbulence. These environmental factors are important, as wind speed and wave height can influence vertical mixing in the upper ocean layer, potentially affecting the concentration and distribution of microplastics in surface waters. Future studies are recommended to incorporate direct measurements of environmental parameters, such as wind speed and wave height, to more accurately assess their influence on microplastic abundance in surface waters.

Laboratory analysis

Water samples were processed using the extraction method done by several researchers **(Masura *et al.*, 2015; Cordova *et al.*, 2019)**. The water samples were subjected to filtration using a 0.45µm Whatman filter paper that had a diameter of 47mm. Subsequently, the sample was subjected to destruction by introducing it into a test tube and introducing 20ml of 30% hydrogen peroxide (Merck Millipore Emprove®) **(Masura *et al.*, 2015; Gewert *et al.*, 2017; Cordova *et al.*, 2019)** This process aimed to isolate the organic components present in the sample. Subsequently, the specimen is subjected to a temperature of 40°C within a water bath (B-One DWBC-30L-6H) for a duration of 36-48 hours, or until the sample achieves a transparent appearance. Following this, the sample is allowed to cool and then filtered using a sterile Whatman filter paper (with a diameter of 47mm and a pore size of 0.45µm), with the assistance of a vacuum pump (Vacuubrand ME 2C**) (Cordova *et al.*, 2020)**. Subsequently, the filter paper was placed in a sterile petri dish (Chazuru CLW E09) and sealed with Parafilm®. Next, a visual examination was conducted to identify microplastics. The approach for identifying microplastics is derived from a study conducted by **Cole *et al.* (2013)**. In this study, samples were placed on filter paper and were examined using an Olympus CX31 microscope at magnifications ranging from 4 to 40 times. A Nikon IMX307 camera connected to S-EYE computer software was used to capture images of the samples. The identification of microplastics relies on specific criteria, including a particle size of ≤ 5mm, a uniform color, the absence of cellular tissue-like shapes, and the absence of branches or segments. Microplastics were detected, enumerated, and quantified. In addition, microplastics were categorized according to their morphology, which can be fragments, fibers, foams, or granules. They were also classified based on their size, which can fall between the ranges of < 300µm, 300–500µm, 500–1000µm, or >1000µm **(Cordova *et al.*, 2019)**. The identification of microplastic polymers was conducted using an Agilent Cary 630 Fourier transform infrared (FTIR) spectrometer equipped with attenuated total reflectance diamond and MicroLab FTIR Software.

Contamination mitigation

Stringent quality control methods were employed for both field sampling and laboratory analysis. These measures involved the utilization of metal or glass receptacles for sample storage, as well as the utilization of cotton gauze sprayed with 70% alcohol to cleanse the microscope and FTIR spectrometer operating platforms before to usage. To assess potential airborne contamination during field observations, an air blank was prepared by placing clean water in an open glass container at the sampling site dan left exposed throughout the observation period. A blank analysis was conducted, revealing the presence of 2 fibers and 2 fragments in the blank sample. During the observation of the samples, the study accounted for both microplastics in the form of fibers and fragments, as well as the microplastic polymer content. Due to their minute dimensions, microplastics have a proclivity to disperse. Therefore, caution must be exercised during the laboratory disposal of microplastics to prevent sample contamination. Sample contamination can occur not only from airborne particles, but also from particles that come from work clothing, equipment, and the surrounding air. Therefore, it has been suggested that processed samples should be kept in a clean environment to minimize this issue **(Duis & Coors, 2016)**.

Statistic analysis

Microplastic abundance in water samples was presented as mean values ± standard deviation (SD), based on three replicate samples (N = 3) collected at each sampling location. Additionally, samples were collected from five different locations (N = 5) during each sampling period, representing the spatial replication across sites. The abundance data and graphs were examined using Microsoft Excel 2010 software for descriptive statistical data analysis. The correlation of water samples for each station was studied using PAST 4.11 software with the Kruskal-Wallis test. A significance level of $P<0.05$ was utilized to determine statistical significance.

RESULTS AND DISCUSSION

1. Abundance of microplastics in Banten Bay waters

Microplastics were detected across the whole sampling area, exhibiting varying total quantities at different observation times and locations (Fig. 2). The quantity of microplastic particles detected at five sampling locations in Banten Bay varied from 0.12 to 1.029 particles/L. In September, the average abundance of microplastics was 0.110 ± 0.255 particles/L, which was the lowest recorded. Conversely, in July, the highest abundance of microplastics was observed, with an average of 0.174 ± 0.145 particles/L. In August, the average concentration of microplastics was 0.119 ± 0.09 particles/L (Fig. 2A). Nevertheless, the statistical analysis did not reveal any noteworthy disparities depending on the month of sampling ($P>0.05$). The abundance in September is greater due to the onset of the transitional season.

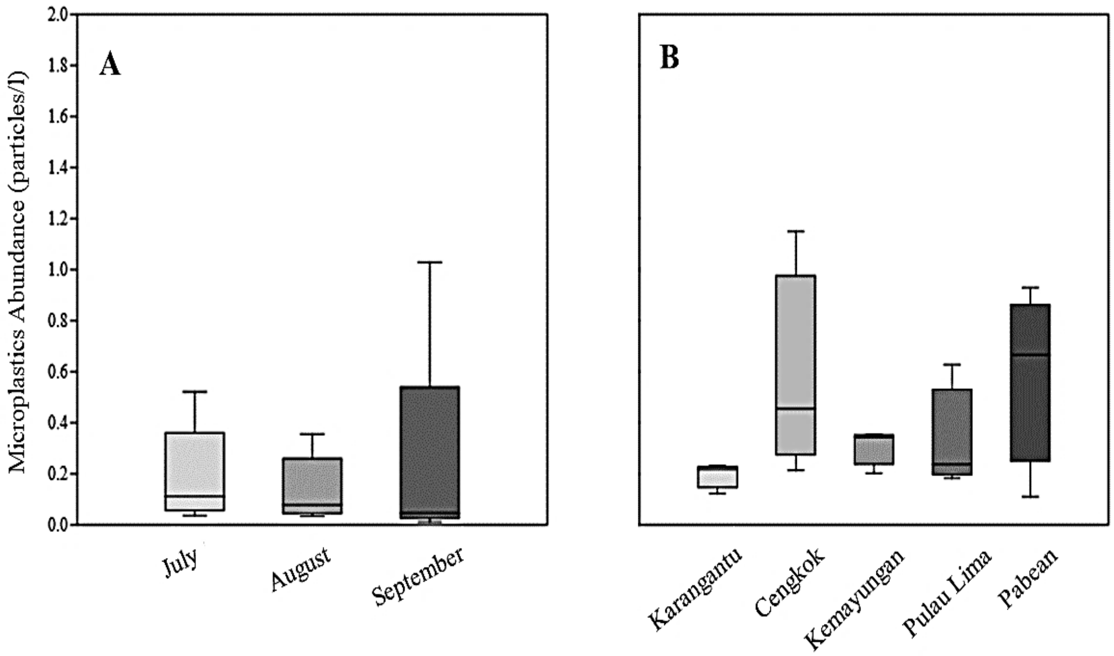

Fig. 1. Microplastic abundance distinguished across months of collection (left) and sampling sites (right)

Based on the collecting locations, it was observed that the Cengkok had the highest average abundance of microplastics, specifically 0.607 ± 0.452 particles/L. According to this study, the Pabean, Pulau Lima, and Kemayungan had the highest abundance values after Cengkok, with average values ranging from 0.568 ± 0.441 to 0.3 ± 0.179 particles/L. On the other hand, Karangantu had the lowest abundance of 0.191 ± 0.024 particles/L. It is worth noting that Karangantu is located near mangrove tourism and fish auctions. Nevertheless, there were no statistically significant variations in the quantity of microplastics when considering the time of sampling ($P > 0.05$) and the region of sampling ($P > 0.05$) (Fig. 2B). The abundance of microplastics exhibits spatial variability, with fluctuations perhaps attributed to community activities.

This presents a juxtaposition of the findings from this study and various other studies that employed comparable methodologies (Table 1). A comparison was made with previous studies conducted in various locations across Indonesia, taking into account the type of sampling equipment used for water collection and the differing characteristics of the aquatic environments where those studies were conducted. Nevertheless, making a direct comparison of microplastic abundance poses challenges because of variations in the employed sample procedures **(Cordova *et al.*, 2022a)**.

Table 1. Comparative analysis of the prevalence of microplastics in terms of quantity, color, size, and form in this study in relation to other investigations

Area	Abudance Average ± SD	Sampling device	Size range dominance	Shape dominance	Years	Reference
Karangantu	0.191 ± 0.024 particle/L	Manta Net	>1000μm	Fragment & Fiber	2022	This Study
Cengkok	0.607 ± 0.452 particle/L	Manta Net	<300μm	Fragment	2022	This Study
Kemayungan	0.3 ± 0.179 particle/L	Manta Net	>1000μm	Fragment	2022	This Study
Pulau Lima	0.349 ± 0.241 particle/L	Manta Net	>1000μm	Fragment	2022	This Study
Pabean	0.568 ± 0.441 particle/L	Manta Net	500-1000μm	Fiber	2022	This Study
Jakarta Bay	4.29 to 23.49×10^3 particles / m³	Manta Net	<300 μm to >1000μm	Fragment	2017	**(Cordova *et al.*, 2022a)**
Palabuhan Ratu Estuary	1.49×10^6 particles / m³	-	1001-2000 μm & 101-200μm	Film & Fragment	2020	**(Pe *et al.*, 2020)**
Benoa Bay	0.43 to 0.58×10^3 particles / m³	Plankton Net	-	Fragment	2018	**(Nugroho *et al.*, 2018)**
Kupang Bay	0.10 to 90.20×10^{-3} particles / m³	Manta Net	-	Fiber	2020	**(Kapo *et al.*, 2020)**

A comparison was made with previous studies conducted in various regions of Indonesia, considering both the sampling tools used and the environmental characteristics of each aquatic site. Recent observations indicate that the coastal waters of Banten, particularly in areas such as Karangantu, Kemayungan, Cengkok, Pulau Lima, and Pabean, are increasingly influenced by various anthropogenic pressures, including coastal development, small-scale aquaculture, domestic wastewater discharge, and increased maritime activity. These localized stressors may contribute to the introduction and accumulation of microplastics in the water column, especially in estuarine zones that serve as convergence points for land-based pollutants. According to **Suteja *et al.* (2021)**, two main factors contribute to the high abundance of microplastics: the first is a high level of pollution, and the second is the type of sampling equipment employed. These factors were taken into account in interpreting the results of the present study. Non-discrete sampling devices like manta nets and plankton nets may fail to retain particles smaller than their mesh size, allowing such particles to escape during collection in the field **(Cutroneo *et al.*, 2020)**.

The presence of microplastics in several bays across Indonesia suggests that activities such as marine transportation and aquaculture contribute significantly to the worsening of microplastic pollution. Estuarine and bay environments act as transitional zones that facilitate the transfer of microplastics from inland waterways to marine ecosystems, aided by tidal movements and ocean currents **(Bessa *et al.*, 2018)**. **Kama *et al.* (2021)** emphasized that approximately 80% of plastic waste found in the ocean originates from rivers, particularly those within large watershed areas.

The detection of microplastics at the five sampling sites in this study is likely linked to the accumulation of plastic waste generated from domestic sources, which enters river systems and is subsequently transported to coastal waters. These areas are influenced by intense anthropogenic activities, such as mangrove-based tourism, fish markets, and aquaculture practices. However, the concentration of microplastics in Banten Bay remains relatively low compared to other urban coastal zones in Indonesia—for instance, Palabuhan Ratu, which measure $1.49\text{x}10^6$ particles/m^3 **(Pe *et al.*, 2020)** and Jakarta Bay with 4.29 to 23.49×10^3 particles/m^3 **(Cordova *et al.*, 2022)**.

2. Composition of shape, size and color of microplastics

Overall, the majority of microplastics in the Banten Bay area are in the form of fragments. Specifically, 52.645% of microplastics were identified at the five observation stations, with an average of 1.106 ± 1.991 particles/L (Fig. 3). Fragment microplastics can originate from robust plastics like bottles, thick plastic bags, and sections of paralon pipes, which gradually break down into smaller sizes due to the effects of UV radiation, exposure to heavy metals, and prolonged product shelf life in aquatic environments **(Ayuningtyas, 2019)**. The fiber form accounts for 41.79% of the total, with a mean of 0.709 particles/L and a standard deviation of 1.122 particles/L. In each observation location, fragments and fibers were discovered. Fiber possesses a reduced density compared to sea water, enabling it to effortlessly float and remain suspended in the water column. Consequently, this form is frequently encountered **(Kowalski *et al*., 2016)**.

According to **Imanuel *et al.* (2022)**, fiber is produced by the breakdown of textile components, trash from washing clothes, and fishing line. It is also thought that the large amount of microplastics in the form of fibers comes from fishing line, fishing nets, and textile waste like clothes, bags, and other fabric materials that have been broken down into tiny particles **(Simamora *et al.*, 2020)**. However, film was only detected in Karangantu and Cengkok, accounting for 5.56% of the total particles/L with an average ± standard deviation of 0.492 ± 0.972 particles/L. Nevertheless, no granular microplastics were detected across all locations and observation periods.

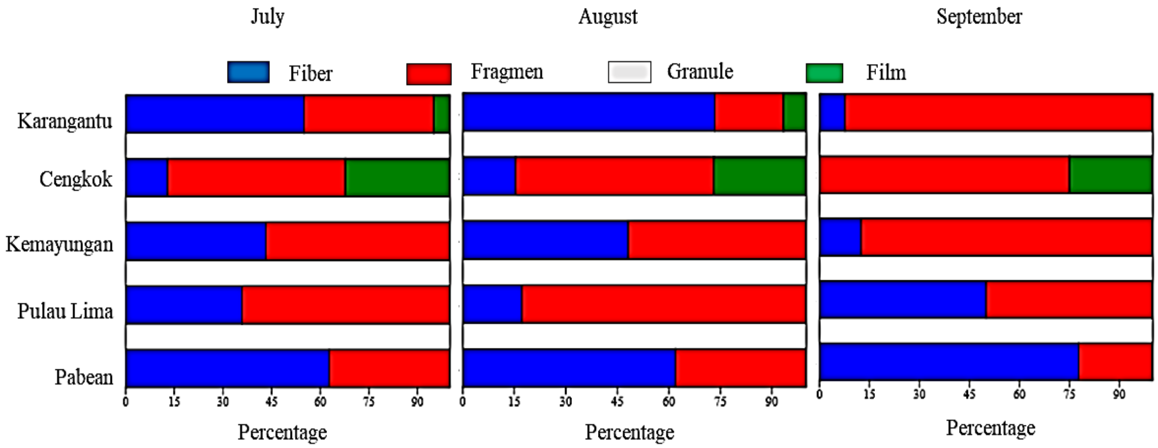

Fig. 2. Percentage of microplastic forms categorized by various locales and time periods

In July, there was a 63% increase in the presence of microplastics in fiber form at Pabean, but in Cengkok, the presence of microplastics in fiber form was just 13%. Pulau Lima is predominantly composed of fragments, accounting for 64% of its composition. In contrast, fragments make up 37% of the composition at Pabean. The film form is present in Cengkok and Karangantu, accounting for 32 and 5%, respectively. The morphology of microplastics in August exhibited minimal variation compared to those seen in July. Karangantu has the highest level of fragmentation at 73%, followed by Pabean at 61%. The lowest level of fragmentation is observed in Cengkok, which is only 15%. Pulau Lima had the highest fragment prevalence at 82%, with Cengkok coming in second at 58%. Kemayungan had a prevalence of 52%, while Pabean and Karangantu had prevalences of 38 and 20%, respectively.

A high proportion of dominating fiber was discovered in September in Pabean (78%) and Pulau Lima (50%). The prevailing fragment was detected in 92% of Karangantu and 87% in Kemayungan. The film format is exclusively present in Cengkok, accounting for only 25% of its content. The film form of microplastics is derived from the decomposition of thin plastic trash, such as plastic bags. Microplastics in this form possess a low density, enabling them to float and remain suspended in the water column **(Imanuel *et al.*, 2022)**. The quantity of microplastics varied significantly depending on the time of collection, as indicated by statistical analysis (P< 0.05). However, the location of sampling did not have a significant impact on the abundance of microplastics, as determined by statistical analysis (*P*> 0.05). The different dimensions of microplastics can be attributed to the degradation induced by mechanical forces acting on some plastics, resulting in their fragmentation and color deterioration **(Forero-López *et al*., 2021)**.

Additional research has also identified different sizes of microplastics in various bodies of water, ranging from 153µm to < 1000µm. Specifically, these microplastics were found in multiple locations in Hong Kong, including the Tsing Yi coast (98,6%), Victoria Harbor (84,2%), Deep Bay (76,2%) dan Tolo Harbor (53,3%) **(Tsang *et al*., 2020)**. Each sampling location exhibited four distinct size categories. In August, microplastics with sizes ranging from 500-1000µm were absent in the waters of Karangantu. However, in September, microplastics measuring 300-500µm were detected in all places, except in the waters of Kemayungan. No microplastics measuring < 300µm and 300–500µm were detected in the Customs waters in September. The prevailing microplastics were of bigger size. Typically, microplastics measuring 500-1000µm were frequently discovered in the five observation sites within the Banten Bay region. Specifically, 32% of the samples included an average of 0.107 ± 0.098 particles/L. Subsequently, there were 29% microplastics that measured > 1000µm. The percentage of these microplastics was found to have a mean value of 0.096 ± 0.081 particles/L (Fig. 4).

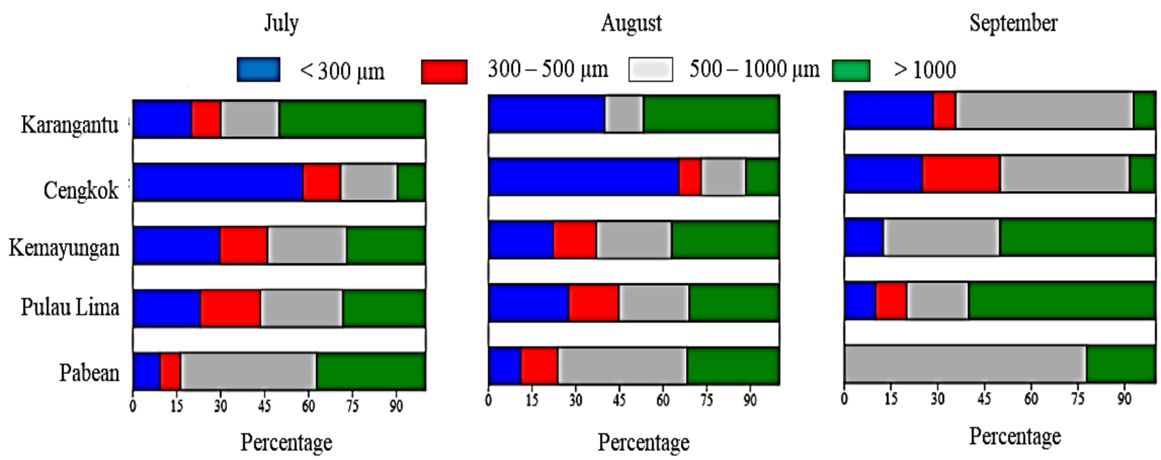

Fig. 3. The size percentage of microplastics is categorized based on various locations and time periods

Measurements of microplastic dimensions conducted in specific months and places exhibit fluctuating dominant sizes. In July and August, microplastics measuring 500-1000µm dominate the Pabean waters, accounting for 46 and 44%, respectively. In September, the percentage of these microplastics increased to 77%. In July, the waters around Pulau Lima had equal proportions of particles measuring 500-1000µm and >1000µm, each accounting for 28% of the total. However, in August and September, larger particles (>1000µm) were more prevalent, making up 31 and 60% of the total, respectively (Fig. 4).

In Kemayungan, the percentage of microplastics measuring less than 300μm was 29.7% in July, 37% in August, and 50% in September. In Cengkok, microplastics measuring less than 300μm are frequently observed, accounting for 58% of the total. In Karangantu waters, microplastics larger than 1000μm are the most prevalent throughout July and August. In September, microplastics measuring 500-1000μm become more dominant, comprising 42% of the total. In Karangantu, microplastics larger than 1000μm were predominantly observed in July and August, accounting for 50 and 47%, respectively. In September, microplastics ranging from 500 to 1000μm were identified in Karangantu. The statistical data indicates a notable disparity depending on the month of sampling ($P < 0.05$), but no significant variation was detected based on the sample location ($P > 0.05$).

The variation in detected microplastic sizes across several aquatic locations in Indonesia is largely attributed to differences in the mesh size of nets or filters used during sampling. For instance, **Ferreira *et al.*, (2020)** collected particles using a 300μm mesh sieve, whereas the present study employed a 0.2μm pore size filter. As a result, smaller size fractions (< 300μm) were underreported in their study. Previous research has demonstrated that particles smaller than 300μm are predominant in sediment samples **(Strand *et al.*, 2019; Bakir *et al.*, 2020)**.

Macroplastics can degrade into smaller fragments known as microplastics, which are increasingly recognized as a more serious threat to aquatic ecosystems and biota. Due to their reduced size and low density, microplastics are highly mobile in the environment, easily dispersed by wind and water currents. Additionally, their surfaces can act as vectors for various pollutants, such as heavy metals and organic compounds, with the adsorption capacity varying based on particle size **(Apetogbor *et al.*, 2023)**. As a result, microplastics are associated with greater toxicological risks and a higher probability of unintentional ingestion by aquatic organisms compared to larger plastic materials **(He *et al.*, 2020)**.

The color of microplastics exhibits variation at different sampling locations, encompassing clear, blue, red, black, white, yellow, green, purple, and brown hues. Transparent microplastics make up 33% of the composition in Cengkok, while in the waters of Karangantu, Kemayungan, and Pulau Lima, blue dominates at percentages of 37, 41, and 26%, respectively. Pabean had a higher prevalence of black microplastics, accounting for 44% of the total. Fig. (4) displays the observable differences in hue among microplastics. The analysis using the Kruskal-Wallis test revealed a significant difference among the colors (P<0.05). However, no significant differences were observed based on location (P>0.05) (Fig. 5).

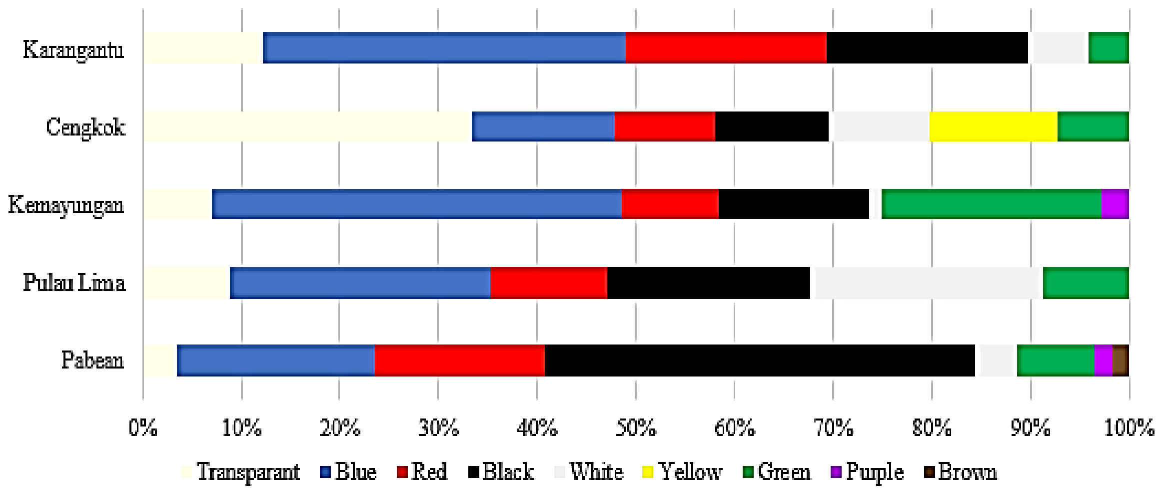

Fig. 4. Color percentage observed at the research site

Transparent hues were detected in five specific locations where water samples were collected during this investigation. Transparant organisms pose a significant threat in aquatic environments due to their resemblance to small jellyfish or zooplankton, which can be easily mistaken for food by marine creatures. Ingestion of these microplastics can lead to detrimental effects on the animals' internal organs **(Nie *et al.*, 2019)**. According to **Wright *et al.* (2013)**, economically significant fish and their offsprings are visually-oriented predators that consume small zooplankton. They have the potential to ingest microplastics that resemble their prey, specifically white, brown, and yellow plastic.

The blue color is prevalent in this study, which aligns with the findings of **Aliabad *et al.* (2019)**, in their investigation of the surface waters of the Gulf of Chabahar. The research has identified colored microplastic particles, including blue, red, yellow, green, purple, and brown. These particles are commonly utilized in various applications, such as plastic food packaging and garment materials. Microplastic color identification is employed to ascertain the primary origin of microplastic particles existence. Microplastic particles undergo color degradation, resulting in fading or transparency. This can be attributed to weathering in aquatic environments, exposure to UV light, and the absorption of heavy metals **(Xu *et al.*, 2018)**.

3. FTIR polymer microplastics

A grand total of 134 particles were visually gathered and examined to verify their microplastic polymer composition. However, only 96 microplastics were positively identified as possessing plastic polymers. The microplastic polymers that have been identified consist of polyester fiber, ethylene prorylene, polypropylene, fiberglass, polyurethene, polyurethane, and polyethylene (Fig. 6).

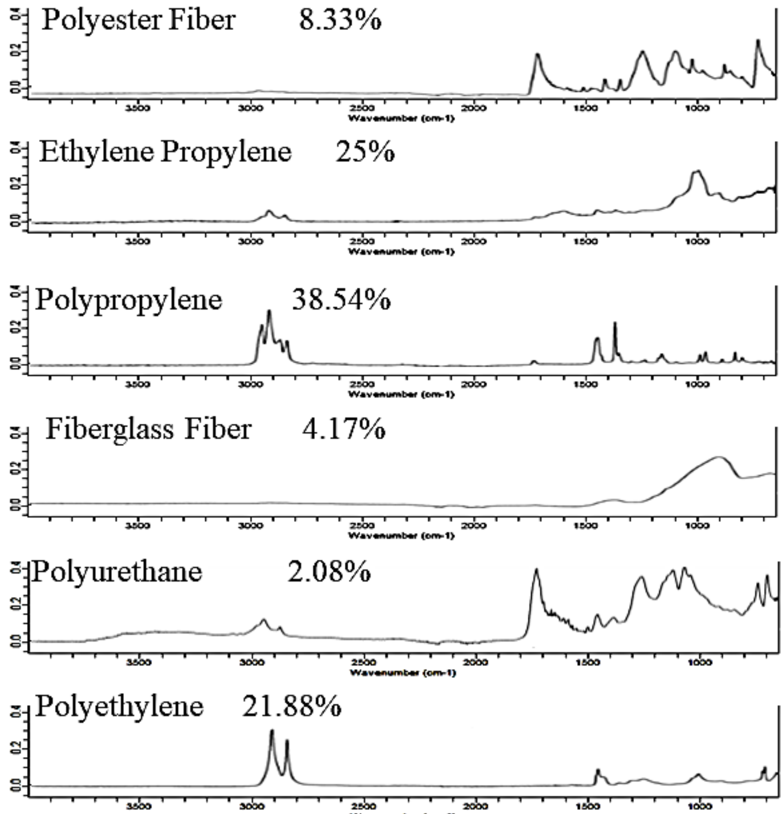

Fig. 5. FT-IR spectra showing microplastic polymer and percentage from Teluk Banten

The polypropylene polymer is the most prevalent, accounting for 38.54% of the total. It is followed by ethylene propylene at 25%, polyethylene at 21.88%, polyester fibers at 8.33%, fiberglass fiber at 4.17%, and polyurethane at 2.08%. The plastic polymers polyethylene, polypropylene, and polyurethane have lower densities than sea water, ranging from 0.91-0.96g/ cm^3, 0.85-0.94g/ cm^3 and 0.40-0.60g/ cm^3, respectively. As a result, these polymers are capable of floating on the surface of water. Consequently, this research discovered a significant presence of these polymers. Polypropylene is commonly seen as it is derived from plastic-based materials used for food packaging **(Xu *et al*., 2018)**. According to a study by **Kutralam-Muniasamy *et al.* (2020)**, polyethylene and polypropylene are the predominant polymers detected in aquatic environments.

CONCLUSION

Microplastics were present in the five sampling locations in Banten Bay—Karangantu, Cengkok, Kemayungan, Pulau Lima, and Pabean—with concentrations ranging from 0.12 to 1,029 particles per liter, indicating varying degrees of pollution across sites. Fragment and fiber types were consistently found throughout the area, while film-type microplastics appeared only at Karangantu and Cengkok, suggesting localized sources or conditions influencing microplastic distribution. The dominant size fraction observed was 500–1000µm, accounting for 32% of the total particles, highlighting the prevalence of medium-sized microplastics in surface waters. In terms of color and polymer composition, blue, black, and clear particles were most common, with polyethylene, polypropylene, and polyurethane being the predominant plastic types. These findings suggest a high level of microplastic contamination likely influenced by anthropogenic activities such as fishing, domestic waste, and industrial discharge, underscoring the urgent need for improved waste management and pollution mitigation strategies in the Banten Bay region.

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