Fisheries Journal, 15 (1), 195-205 (2025)
http://doi.org/10.29303/jp.v15i1.1290

CHARACTERISTIC AND DISTRIBUTION OF MICROPLASTIC IN PASARAN ISLAND WATERS, BANDAR LAMPUNG

Karakteristik dan Persebaran Mikroplastik di Perairan Pulau Pasaran, Bandar Lampung

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(Received November 19th 2024; Accepted January 20th 2025)

ABSTRACT

Microplastics are plastic particles formed from plastic degradation to a size of <5 mm. Microplastics in waters can have adverse effects on marine organisms, aquatic ecosystems, and humans. This study aims to determine the shape, size, color, abundance, and distribution of microplastics and to determine the relationship between water quality and the abundance of microplastics in the waters of Pasaran Island. The study was conducted in November-December 2022 in the waters of Pasaran Island. Preparation and identification of microplastics in water samples were carried out in the following stages: sample preparation, organic material degradation, density separation, sample sorting, and observation of microplastic types. Data analysis was carried out using the principle component analysis (PCA) method using the Statistical Program for Social Science (SPSS) version 24 with physical and chemical parameters of the waters. Based on the study, 4 forms of microplastics were obtained, namely fiber, fragments, films, and pellets. The form of microplastic that dominated the four stations was the fiber form at 45.1%. The highest abundance of microplastics was at Station 2 (mangrove ecosystem) at 22.63 particles/liter. PCA analysis showed that the abundance of microplastics in the form of fibers, fragments, films, and pellets was negatively related to pH, salinity, current, temperature, and brightness. Increasing public awareness in reducing the use of single-use plastics and managing plastic waste needs to be done to reduce the abundance of microplastics in the waters of Pasaran Island.

Key words: Abundance, Distribution, Microplastics, Water quality

ABSTRAK

Mikroplastik merupakan partikel plastik yang terbentuk dari degradasi plastik hingga berukuran < 5 mm. Mikroplastik yang berada di perairan dapat berdampak buruk terhadap organisme laut, ekosistem perairan, dan manusia. Penelitian ini bertujuan mengetahui bentuk, ukuran, warna, kelimpahan, dan persebaran mikroplastik serta mengetahui hubungan kualitas perairan dengan kelimpahan mikroplastik di perairan Pulau Pasaran. Penelitian dilaksanakan pada Bulan November-Desember 2022 di Perairan Pulau Pasaran. Preparasi dan Identifikasi mikroplastik pada sampel air dilakukan dengan tahapan: persiapan sampel, degradasi bahan organik, pemisahan densitas, pemilahan sampel, dan pengamatan jenis mikroplastik. Analisis data dilakukan menggunakan metode *principle component analysis* (PCA) menggunakan Statistical Program for Social Science (SPSS) versi 24 dengan parameter fisika dan kimia perairan. Berdasarkan penelitian diperoleh 4 bentuk mikroplastik yaitu fiber, fragmen, film, dan pelet. Bentuk mikroplastik yang mendominasi pada keempat stasiun yaitu bentuk fiber sebesar 45,1%. Kelimpahan mikroplastik tertinggi berada pada Stasiun 2 (ekosistem mangrove) sebesar 22,63 partikel/liter. Analisis PCA menunjukkan bahwa kelimpahan mikroplastik bentuk fiber, fragmen, film, dan pelet berhubungan negatif dengan pH, salinitas, arus, suhu, dan kecerahan. Peningkatan kesadaran masyarakat dalam mengurangi penggunaan plastik sekali pakai dan pengelolaan sampah lastik perlu dilakukan untuk mengurangi kelimpahan mikroplastik di Perairan Pulau Pasaran.

Kata Kunci: Kelimpahan, kualitas air, mikroplastik, sebaran

INTRODUCTION

Pasaran Island is an island located in the coastal area of Bandar Lampung City with an area of 12.5 hectares (Noor *et al*., 2021). Pasaran Island functions as a center for fish processing, cultivation, ship traffic routes in the waters of Lampung Bay, and a place for fishermen to live. Pasaran Island has a fairly dense population. The dense population activity is the cause of the increase in the amount of plastic waste production. Plastic waste also comes from the mainland of Bandar Lampung City which enters Pasaran Island through the Way Belau River which flows into Pasaran Island. According to data from the Lampung Provincial Environmental Service in 2020, the coastal communities of Lampung Bay can produce 183 tons of plastic waste/year. This plastic waste can come from fishing, tourism, and household activities that are not managed properly.

Plastic waste in waters can undergo a degradation process that can break down plastic into smaller pieces (Ridlo *et al*., 2020). Plastic that is less than 5 mm in size is called microplastic (Lange *et al.,* 2022). Microplastics can come from plastic particles that are deliberately produced in small sizes, such as cleaning products, or from larger plastic fragments (Austen *et al.,* 2022). Microplastics in large quantities in waters can have a negative impact on the environment (Hafidh *et al.,* 2018).

The small size of microplastics can make them more easily ingested by aquatic organisms (Esterhuizen *et al.,* 2022), which can then damage internal organs such as digestive tract disorders (Dodson *et al.,* 2020), inhibit growth (Carbery *et al.,* 2018), and disrupt the reproductive system (Meyers *et al.,* 2022). Microplastics ingested by aquatic organisms can accumulate and move to higher trophic levels through the food chain (Esterhuizen *et al.,* 2022) and can cause health problems in humans (Sharma *et al.,* 2017). Therefore, research is needed to identify the shape, color, size, abundance and distribution of microplastics and analyze the relationship between water quality parameters and microplastic abundance in the waters of Pasaran Island, Teluk Betung Timur District, Bandar Lampung.

RESEARCH METHODS

Time and Place

The study was conducted in November-December 2022. Microplastic sampling was carried out in the waters around Pasaran Island consisting of four stations. Analysis of microplastic forms was carried out at the Aquatic Productivity Laboratory, Faculty of Agriculture, University of Lampung.

Tools and Materials

The tools used in this study were cool box, Plankton net, GPS (Global Positioning System), digital camera, pH meter, refractometer, Secchi disk, current meter, glass funnel, sample bottle, stationery, Whatmann paper (41), aluminum foil, incubator, beaker glass, measuring cup, petri dish, hotplate stirrer and stereo microscope. The materials used were Hydrogen peroxide (H_2O_2) 30%, solid Sodium chloride (NaCl), distilled water, label paper, and tissue.

Determination of Research Stations

Determination of sampling stations using the purposive sampling method (Dhea *et al.,* 2023). Each station consists of three repetition points. Station 1 is the Way Belau River, Station 2 is the mangrove ecosystem, Station 3 is the location of green mussel cultivation (*Perna viridis*), and Station 4 is the waters near the settlement.

Water Sampling

Water sampling was carried out twice with a sampling interval of two weeks. Water samples were taken using two sampling methods, namely active and passive. Active sampling was carried out at Stations 1, 3 and 4. Active sampling was carried out by pulling a plankton net on the side of the ship at a distance of 1 meter (Hafidh et al., 2018). During sampling, the time, distance, and coordinate points were recorded using GPS, as well as the average speed of the ship. Passive sampling was carried out at Station 2 (mangrove ecosystem) using a plankton net and the help of a 10L bucket to collect water (Cahya *et al.,* 2019). The filtered sample of 200 ml was transferred into a glass sample bottle and labeled, then the sample was put into a cool box for analysis in the laboratory.

Identification and Quantification of Microplastics

Identification of microplastic particles in water samples refers to Masura *et al.* (2015), carried out in several stages. The first stage is filtering the sample using whatmann paper no. 42 with a diameter of 90 mm, then the sample is transferred into a beaker glass. The second stage is the destruction of organic matter using 20 ml of 30% H_2O_2 solution. The stage of increasing the density of the solution is carried out by adding 6 grams of NaCl per 20 ml of sample (Yona *et al.,* 2021). The third stage, the sample is placed on a hotplate stirrer at a temperature of 40-60°C for 30 minutes, then the beaker glass is covered with aluminum foil and left for 12 hours at room temperature. The fourth stage, the sample is filtered using whatmann filter paper no. 42 with a diameter of 90 mm, then placed on a petri dish and allowed to dry to continue to the identification stage using a stereo microscope. The abundance of microplastics is calculated using the following formula (NOAA, 2013).

The volume of water filtered by the plankton net is obtained by multiplying the mouth area of the plankton net by the distance the plankton net is pulled (Yona et al., 2021).

$$\text{Microplastic abundance} = \frac{\text{Number of microplastics (partikel)}}{\text{Volume of filtered water (m}^3\text{)}}$$

$$\text{Volume of filtered water} = \pi r^2\, x \text{ draw distance}$$

Analysis of the Relationship between Microplastic Abundance and Water Quality Parameters

The relationship between microplastic abundance and water quality parameters (salinity, current, temperature, brightness, and pH) at each station was analyzed using principle component analysis (PCA) using the Statistical Program for Social Science (SPSS) version 24.

RESULT

Identification of microplastics in water samples from four different stations, four forms of microplastics were obtained, namely fragments, films, fibers, and pellets (Figure 1).

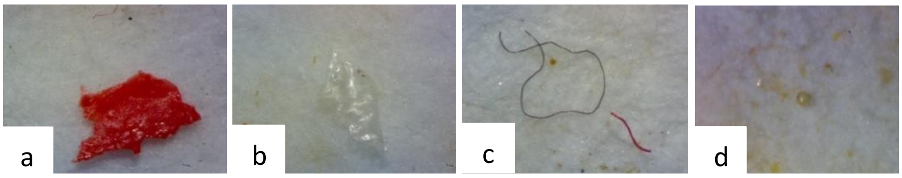

Figure 1. Microplastic forms consisting of (a) fragments, (b) films, (c) fibers and (d) pellets.

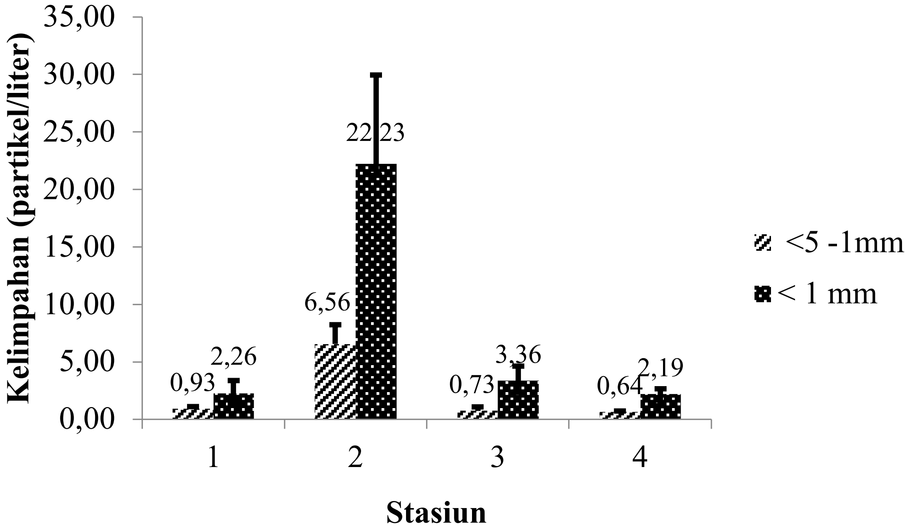

Figure 2. Diagram of microplastic abundance by size

The highest percentage of microplastic forms at all stations was fiber (45.45%) followed by fragments (33.65%), films (20.60%), and pellets (0.3%). Fiber was the most common form found. Microplastics in the waters around Pasaran Island have different sizes. The difference in size in microplastics can be influenced by the length of the plastic degradation process. Microplastics at Station 1 were between 3.439-0.019 mm, Station 2 3.929-0.021 mm, Station 3 3.806-0.017 mm, and at Station 4 the size ranged from 4.899-0.012 mm (Figure 2).

Based on the color, the microplastics found with the highest percentages were black at 48.37%, red at 20.11%, and blue at 13.50% (Figure 3).

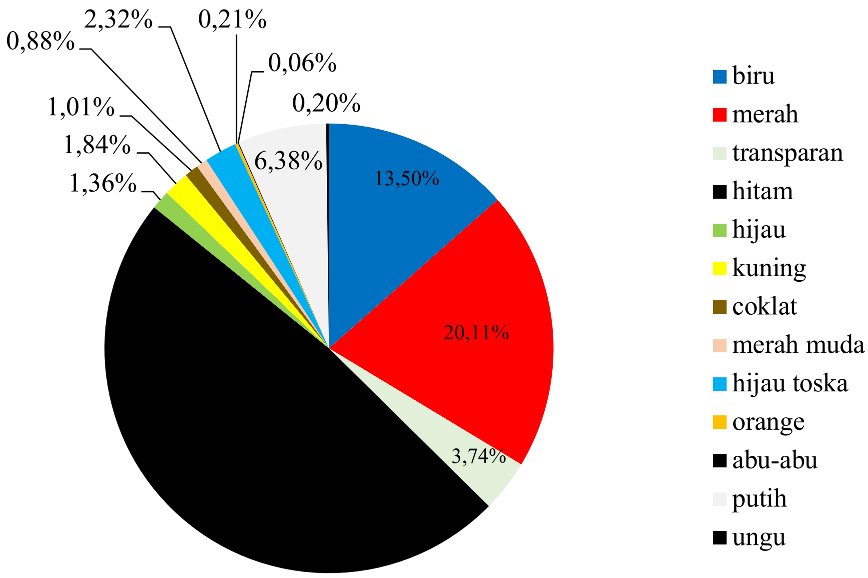

Figure 3. Percentage of microplastics by color

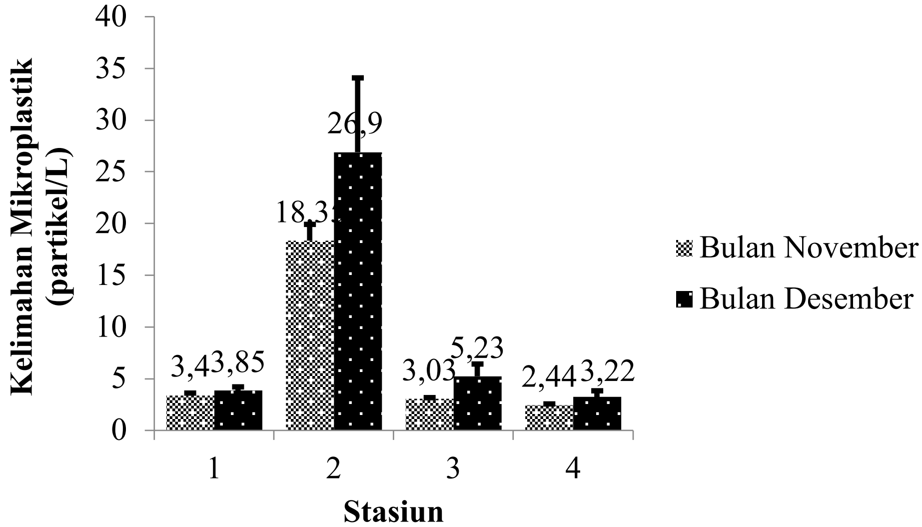

Figure 4. Comparison diagram of microplastic abundance based on observation time.

The abundance of microplastics found at each station was different and increased based on the observation time. The abundance of microplastics in December at all stations was higher than in November (Figure 4). The highest average abundance was found at Station 2, which was 22.63 particles/l. The next highest average abundance was at Station 3 (4.13 particles/l). The average abundance of microplastics at Station 1 was 3.63 particles/l. The smallest average abundance of microplastics was found at Station 3 (2.83 particles/l).

Based on the microplastic distribution map (Figure 5), it can be seen that the distribution of microplastics on Pasaran Island is influenced by community activities. The distribution at station two (mangrove ecosystem) shows a higher abundance than other stations. The distribution of microplastics at stations one, three, and four shows a relatively similar abundance, namely <2 particles/l in each form.

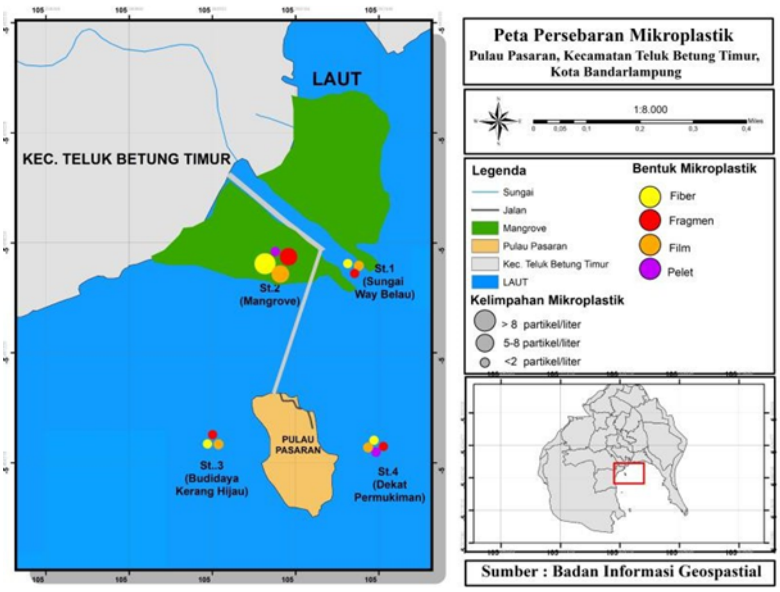

Figure 5. Map of microplastic distribution in the waters of Pasaran Island

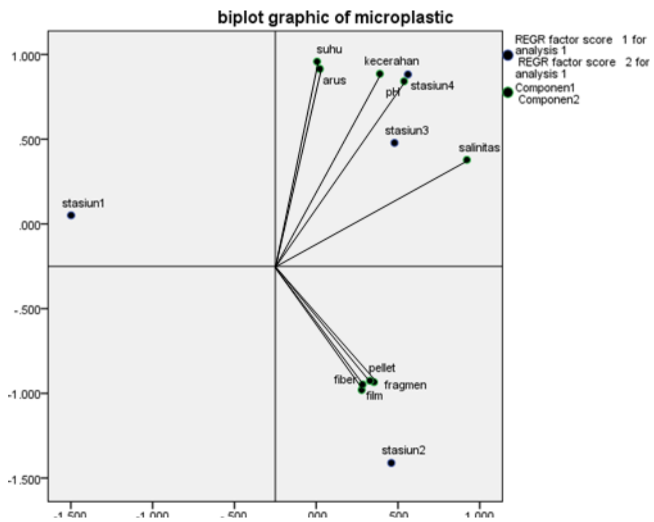

Figure 6. Biplot of the relationship between water quality and microplastic abundance.

The results of the PCA analysis (Figure 6) show that current speed is negatively correlated with the abundance of microplastics in the form of fibers of -0.841, fragments of -0.821, films of -0.805, and pellets of -0.766. Temperature is negatively correlated with the abundance of fibers of -0.895, fragments of -0.875, films of -0.867, and pellets of -0.833. The abundance of microplastics in the form of fibers, fragments, films, and pellets at station two is correlated with the pH parameter. The brightness parameter is negatively correlated with the abundance of microplastics in the form of fibers of -0.759, fragments of -0.706, films of -0.766, and pellets of -0.740.

DISCUSSION

Fiber is a form of microplastic that is found to dominate at each station. This form is usually produced from synthetic fabrics from washing (Cordova *et al*., 2019), fishing boat waste and fishing gear such as nets and fishing lines (Napper *et al.,* 2022). Fragments are a form of microplastic produced from the fragmentation of large waste such as plastic bottles, thick food packaging, and broken PVC pipes (Susanti *et al.,* 2022). Film is a form that has the characteristics of being transparent, thin, and easy to transport (Ayuningtyas *et al.,* 2019). This form can come from degraded plastic bags (Coppock *et al.,* 2021). Pellets can come from plastic making materials, facial cleansers, and cosmetic scrubbers (Cordova *et al.,* 2019; Austen *et al.,* 2022). The high percentage of fiber forms in the waters of Pasaran Island comes from waste from residents' activities such as fishing on the banks of the river and laundry waste that is carelessly disposed of by the surrounding community. These results are similar to the form of microplastics found in the waters of Tegal Mas Island, Teluk Pandan District, Pesawaran Regency, Lampung, which are dominated by fiber forms (10.8 particles/m3) (Octarianita *et al.,* 2020). Fiber can have a negative impact on marine organisms because it can form knots (Johan *et al.,* 2021) and block the entry of food into the digestive system of aquatic organisms (Meyers *et al.,* 2022).

The dominant microplastics found at each station were small (<1 mm). The results of this study are in line with previous studies that found microplastics measuring 500-1000 µm dominated in the Changjiang Estuary, China (Zhao *et al.,* 2019). Differences in microplastic size can usually be caused by the length of the fragmentation process (Sekarwardhani *et al.,* 2022). The longer the plastic is in the water, the smaller the plastic waste will be (Bilal *et al.,* 2020). Other factors that can affect the size of microplastics are sea waves, climate change, and other abiotic factors (Sawalman *et al.,* 2021). Small microplastics (<1 mm) can have harmful effects on aquatic organisms (Cordova *et al.,* 2020) because microplastics are more easily ingested by aquatic organisms (Xia *et al.,* 2020) and affect the aquatic food chain (Dodson *et al.,* 2020).

Identification of microplastics based on their color, it is known that black is found with the highest percentage. The black color in microplastics can be caused by the large number of contaminants absorbed by microplastics (Kapo *et al.,* 2020). According to Johan *et al.* (2021) the black color comes from plastic bags that are generally used by the local community and the plastic degrades to produce microplastic particles. Different colors can come from the initial color of the plastic before it degrades into microplastics. (Dewi *et al.,* 2015). Dewi *et al.* (2015), explained that the color of microplastics can also be influenced by prolonged exposure to UV rays until the color fades.

The results of the abundance of microplastics in the waters of Pasaran Island show that the highest abundance of microplastics is at Station 2. At Station 2, the abundance of microplastics can be generated from piles of plastic waste caught in sediment and mangrove roots. The waste comes from waste that is directly dumped around the mangrove ecosystem because there is no temporary waste disposal site. In addition, it can also come from waters that are carried by currents and trapped in mangrove roots (Ayuningtyas *et al.,* 2019). Microplastics in the waters can come from the fragmentation of plastic waste carried by currents, wind or tides (Kapo *et al.,* 2020). The next highest abundance is Station 3, at this station the abundance of microplastics can come from the activities of the surrounding community such as fishing carried out around the green mussel (*Perna viridis*) cultivation location. In addition, this station is a fishing boat traffic route. According to Napper *et al.* (2020) microplastics can be generated from the remains of fishing gear used by fishermen in fishing activities. The abundance of microplastics at Station 1 is dominated by fiber forms that can be produced from the activities of the surrounding community such as fishing around the river. This is in accordance with the research of Baldwin *et al.* (2016), who found 71% of fiber forms in the waters of the Great Lake River and the research of Kapo *et al.* (2020), who found the highest abundance of microplastics in the form of fibers of 0.0902 particles/l. Rivers are a significant contributor of plastic waste with an amount of between 1.15-2.41 million tons each year (Lebreton *et al.,* 2017). The presence of microplastics in river estuaries can be influenced by human activities, where the presence of humans will increase microplastic pollution

(Hitchcock *et al.,* 2019). The lowest abundance of microplastics was at Station 4. At this station, the abundance of microplastics can come from anthropogenic waste that is carelessly dumped by residents on the beach. In addition, waste can also come from outside Pasaran Island because this station is directly adjacent to the waters of Lampung Bay. Boucher and Friot (2017), explained that 98% of microplastics in the waters are the result of land activities. The low abundance of microplastics at this station can be caused by the stronger current speed than other stations so that microplastics are transported to other places (Lestari *et al.,* 2019).

The distribution of microplastics in the waters of Pasaran Island is influenced by the activities of the surrounding community. The distribution at station two (mangrove ecosystem) shows a higher abundance than other stations. The distribution of microplastics at stations one, three, and four shows a relatively similar abundance, namely <2 particles/l in each form. This can be caused by the input of waste that is still in one flow and the distance between each station is not too far. The abundance of microplastics can be produced from household waste that is disposed of carelessly (Cordova *et al.,* 2019) and pieces and remains of fishing gear (Napper *et al.,* 2022). Ariyunita *et al.* (2022), stated that microplastics can be produced from the remains of fishing gear used by fishermen in fishing activities.

Based on the results of the PCA analysis, current parameters are negatively correlated with microplastic abundance. The highest average microplastic abundance value was found at station two at 22.63 particles/l with the lowest current value ranging from 0.1-0.3 m/s. Increasing current speed will reduce the abundance of microplastics, including fibers, fragments, films, and pellets. Currents easily transport microplastics that have small densities and sizes (Bagaskara *et al.,* 2020). The higher the current speed in a body of water, the faster the microplastics will move to other places (Wulandari *et al.,* 2022). Temperature parameters are negatively correlated with microplastic abundance. Increasing water temperature can reduce microplastic abundance because heat can accelerate the plastic degradation process (Yona *et al.,* 2021). The longer the plastic undergoes degradation, the smaller the plastic will be and the easier it will be to move (Eriksen *et al.,* 2013). The abundance of microplastics in the form of films, fibers, fragments, and pellets at Station 2 is correlated with pH parameters. pH affects the life of bacteria in the waters, where these degrading bacteria help in the plastic degradation process (Wahyuni, 2017). Salinity is negatively correlated with the abundance of microplastics in the form of pellets, fragments, films, and fibers. Microplastics can sink or float because the density of microplastics is lighter than seawater (Hamuna *et al.,* 2018). The ability of microplastics to float determines the position and interaction of microplastics in the waters (Nainggolan *et al.,* 2022). Brightness is negatively correlated with the abundance of microplastics in the form of fibers. The brightness at station four was higher than the other stations, which was 198.75 with the lowest total microplastic abundance value of 2.83 particles/l. Waters that have low brightness values contain many suspended particles, both dead particles such as organic materials and living particles such as plankton and bacteria, where bacteria are able to help the plastic degradation process in the waters (Hamuna *et al.,* 2018).

CONCLUSION

Microplastics found in the waters around Pasaran Island are predominantly <1 mm in size consisting of four forms, namely pellets, fibers, films, and fragments, while based on their dominant colors, they are black, red, and blue. The highest abundance of microplastics was at Station 2 at 22,625 particles/l, then Station 3 at 4.13 particles/l, Station 1 at 3.63 particles/l, and Station four at 2.83 particles/l. Analysis (PCA) showed that the abundance of microplastics was negatively correlated with the parameters of temperature, current, pH, salinity, and brightness.

Increasing public awareness in reducing the use of single-use plastics and replacing them with environmentally friendly products, as well as the existence of a good waste management system is very much needed in order to control the increase in the abundance of microplastics in the waters of Pasaran Island and avoid impacts on the community.

ACKNOWLEDGEMENTS

On this occasion, the author would like to thank the parties involved in this study. Hopefully this study can be information in waste management, especially in coastal areas.

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