Microplastic Contamination in Coastal Waters of South Larompong, Luwu, South Sulawesi, Indonesia

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ABSTRACT. Microplastic contamination in the aquatic environment poses a serious threat to the survival of the ecosystem because it is persistent. Plastic waste comes from various anthropogenic activities that accumulate and spread in coastal waters to deep seas around the world including the waters of South Larompong. This study aims to analyze the concentration of microplastics in the water column in the coastal waters of South Larompong. Sampling was carried out using the volume reduce method with the neuston net at four stations, namely Bonepute Beach, Ponnori Beach, Babana Beach and Damaci Beach. The results showed that there was microplastic contamination and found as many as 186 microplastic particles with an average concentration of 2.68 particles/m³. The results of the analysis of microplastic concentrations showed significant differences (P<0.05) between stations. The highest concentrations of microplastics are found on Bonepute Beach which is an area of aquaculture, fishing and densely populated settlements, then followed by Ponnori Beach which is a tourist area. Meanwhile, the lowest microplastic concentrations are found on Babana Beach, which is the estuary area of the Temboe River and Damaci Beach which is a nearby area. Several forms of microplastics were found, namely granules, fibers, films and fragments which were the most dominant forms. Several colors of microplastics were found, namely blue, brown, green, red, white, and black which were the most dominant colors. There are two types of polymer found, namely HDPE (High Density Polyethylene) and PVA (Polyvinyl alcohol). The conclusion of this study is that the coastal waters of South Larompong have been contaminated with microplastics so that more attention is needed regarding the handling of plastic waste, especially microplastics.

1. Introduction

Plastic pollution is a global issue today because the degradation process takes a long time so that it has a very detrimental impact on nature, especially marine ecosystems. About 8 million tonnes of plastic each year are dumped into the sea and 1% consists of small plastic debris. From the research results of Jambeck et al. (2015), information was obtained that Indonesia ranks second in the world as the largest contributor to plastic pollutants to the ocean after China. In this study, it was emphasized that the amount of plastic waste produced by Indonesia is more than 5.4 million tons and around 0.48-1.29 million tons ends up in the sea every year. The ultimate goal of plastic disposal is the ocean and it can take hundreds of years for plastic waste to degrade in nature. Plastics that have undergone a degradation process are known as microplastics (Aymoonngyas et al., 2019).

Microplastics are plastic fragments less than 5 mm in size with various sizes, colors, shapes, density and chemical composition (Abreu & Pedrotti, 2019; Barboza et al., 2018; Choudhury et al., 2018; Critchell & Hoogenboom, 2018; Espiritu et al., 2019; UNEP, 2016; Wessel et al., 2016). Basically, microplastics are differentiated between primary microplastics and secondary microplastics based on their source (Lemoine et al., 2018; Malafaia et al., 2019; Rehse et al., 2018). Primary plastics that are produced in micro sizes from the start such as in adhesive products, composites, tires, balloons, toothpaste, bath soap, scrubs and cosmetics are called primary microplastics while the breakdown results of large plastics such as household furniture, fishing gear, boats and packaging food into small plastics is called secondary microplastic (Schwarz et al., 2019).

Microplastics in marine environments are usually found as pellets, fragments or fibers and consist of a variety of polymers, some of which have a higher density than seawater and will sink to the seabed such as Polyamide, Polyester, Polyvinyl Chloride (PVC) and Acrylic. Meanwhile, microplastics with a lower density than seawater will float on the surface such as polyethylene, polypropylene and polystyrene (Smith et al., 2018). Various types of plastics are produced globally, but 6 types of plastics dominate the market: polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), polyurethane (PUR) and polylethyene terephthalate (PET) (GESAMP, 2015; Hastuti et al., 2019; Prokic et al., 2019).

Hiwari et al. (2019) stated that the sources that are indicative of microplastic waste production are household activities, tourists, fishermen, traders, industry and transportation. These various activities directly or indirectly contribute greatly to plastic pollution in the waters. One of the waters in Indonesia, namely the waters of South Larompong has a high potential for microplastic pollution. Larompong Selatan District has an area of 131 km² and is located in Luwu Regency, South Sulawesi Province. Along the coastline, there is a stretch of white sand which is used as a tourist destination, such as the Ponnori Beach, where visitors’ activities can be a source of plastic pollution in these waters. There is also the estuary of the Temboe River in the Banana Beach area where along the river there are settlements that have the potential to contribute plastic waste to the river and then carried by the current to the ocean. In addition, Damaci Beach, which is the waters close to the ponds, also has the potential to be contaminated by microplastics from the remains of pond activities. The potential for microplastic pollution is also found on Bonepute Beach which comes from various activities of the population such as aquaculture and fishing as well as household waste.

Based on the literature study conducted, there has been no research or information regarding microplastic pollution in South Larompong waters. It is necessary to conduct research on the concentration of microplastics in waters based on regional representation such as tourist areas, river estuaries, fisheries areas
2. Material and Methods

2.1. Tools and Materials

The tools used in this research include: neuston net (mesh size 330 µm to filter water samples, cool box as a container for storing water sample bottles, boats as a means of transportation to take water samples, sample bottles as water sample containers, Global Position System (GPS) to determine the point of location for water sampling, a vacuum pump to separate the water sample from microplastic particles, a stereo microscope to observe microplastics and some laboratory tools such as scale pipette, beaker, stirring rod, scales, glass preparation, petri dish and tweezers.

The materials used in this study include: water samples as the material being observed, 47 mm Whatman filter paper to filter the samples, KOH to destroy organic matter and soft cloth / tissue to clean the tools used.

2.2. Study Area

The sampling locations were carried out at four stations in the waters of Larompong Selatan District, Luwu Regency, South Sulawesi (Figure 1). The station was determined based on the purposive sampling method by looking at the different anthropogenic activities around the waters so as to allow for differences in the concentration of microplastics at each station.

Purposive sampling method is one of the non-random sampling methods to determine sampling by determining special characteristics that are in accordance with the research objectives so that it is expected to be able to answer research problems (Wang et al., 2019). Station I is located on Bonepute Beach which is a densely populated residential area and close to seaweed cultivation and fishing, Station II is located on Ponnori Beach which is a tourist and residential area, Station III is located on Babana Beach which is an estuary area while Station IV is located on Damaci Beach which is the waters close to the pond.

Determination of the coordinates of each station is done using GPS (Global Positioning System). The coordinates of each station are: station I is at coordinates 3°38'38''S 120°24'55''E, station II is at coordinates 3°37'46''S 120°25'10''E, station III is at coordinates coordinate point 3°37'10''S 120°25'12''E and station IV is at coordinate point 3°36'01''S 120°25'26''E.

2.3. Sampling

The research was carried out for three months starting from June to August 2020. Sampling is only conducted once in June during the day when the tide is high. Sampling was carried out at four stations with four repetitions at each station (Afdal et al., 2019). Illustration of water sampling can be seen in Figure 2.

Microplastic sampling in the waters was carried out using the volume reduce method using the Neuston net with a mesh size of 330 µm, a net length of 75 cm and a mouth opening width of 60 x 15 cm. Neuston net is pulled in the direction of the coastline as far as 200 m using a rope with a boat when the sea water conditions are high to facilitate the passage of the boat (Solomon & Palanisami, 2016). The filtered water sample in the Neuston net bottle was transferred to the sample bottle and given a station marker, after which the water sample was stored in a cool box for further analysis in the laboratory.

Figure 1. Map of sampling locations. Source: Google Satellite 2020.
Samples were stored in a low temperature room of 20°C. Furthermore, the samples were filtered using 47 mm Whatman filter paper with a pore size of 0.45 µm with a vacuum pump. The filter paper that has been used to filter the water sample is then transferred to a cleaned Petri dish. The filter paper with a pore size of 0.45 µm with a vacuum pump. The filter paper that has been used to filter the water sample is then transferred to a cleaned Petri dish.

2.4. Sample Processing and Microplastic Characterization

2.4.1. Laboratory analysis

Laboratory analysis were carried out at the Laboratory of Productivity and Water Quality, Department of Fisheries, Faculty of Marine and Fisheries Sciences, Hasanuddin University, Makassar. First, sample preparation is carried out in the form of transferring the water sample from the sample bottle into a beaker. In laboratory analysis, water samples were given KOH with a concentration of 1% (Kühn et al., 2017) to dissolve organic substances then the water samples were stored in a low temperature room of 20°C (Thiele et al., 2019). Water samples that have been given KOH solution are left to stand for 24 hours to dissolve and bleach organic material so that it is easier to visually identify microplastics using a microscope. Furthermore, the samples were filtered using 47 mm Whatman filter paper with a pore size of 0.45 µm with a vacuum pump. The filter paper is then transferred to a cleaned Petri dish.

2.4.2. Microplastic identification

The filter paper that has been used to filter the water sample is then transferred to a glass slide using tweezers to calculate and observe visual characteristics such as color, shape and size. Microplastic identification was carried out using a stereo microscope with a magnification of 4 times. Each microplastic sample found is then documented for further length measurements using Image J software which has been calibrated first. The number, size, color and shape of the microplastics for each sample were recorded. The microplastic concentration was calculated by comparing the number of particles found with the volume of water filtered (Wang et al., 2019).

2.5. Fourier Transform Infrared Spectroscopy (FTIR) Analysis

After analyzing the visual characteristics, the microplastic samples on the filter paper were sorted by shape or color and then transferred to a glass preparation and carried out by the FTIR (Fourier Transform Infrared) test. FTIR analysis were carried out at the Integrated Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Hasanuddin University, Makassar. Spectroscopy FTIR testing was carried out to determine the type of microplastic polymer (GESAMP, 2015; Zhang & Chen, 2019). The analysis was carried out at the Integrated Chemistry Laboratory of the Faculty of Mathematics and Natural Sciences Hasanuddin University using the Fourier Transform Infrared (FTIR) Shimadzu IR Prestige-21 spectrometer. The polymer type readings were carried out using the Open Specy software https://wincowger.shinyapps.io/OpenSpecy/.

2.6. Statistical Analysis

Statistical data analysis was performed with Graphpad Prism software using one-way ANOVA test to analyze the comparison of microplastic concentrations at four different stations. Prior to the one-way ANOVA test, the normality and homogeneity tests were carried out. Data that were normally distributed and homogeneous were followed by a one-way ANOVA parametric test. Meanwhile, data that were not normally distributed were transformed and then tested again for normality and homogeneity. The normal data was followed by a one-way ANOVA parametric test. However, the data were not normally distributed and / or not homogeneous, followed by a non-parametric one-way ANOVA test (Kruskal-Wallis test).

3. Results and Discussion

Observation of water samples indicated that there was microplastic contamination and obtained 386 microplastic particles. The concentration of microplastics is the ratio between the number of microplastic particles obtained and the volume of filtered water. In this study, the volume of filtered water per substation was 9 m³. The comparison of the microplastic concentration for each station can be seen in Figure 3.

The concentration of microplastics at station I was 4.06 particles / m³, station II was 3.86 particles / m³, station III was 1.39 particles / m³, station IV was 1.42 particles / m³. The results of statistical tests using one way ANOVA analysis showed that the concentrations of microplastics at four stations were significantly different (P <0.05). The difference in concentration was found between stations I and III, stations I and IV, stations II and III and stations II and IV.

South Laronmpong waters have several sources of microplastic waste such as household waste, tourist areas, aquaculture and fishing as well as river estuaries. The high anthropogenic activity around the waters causes a high chance of finding microplastics in the waters (Auta et al., 2017; Schwarz et al., 2019). In this study, the concentration of microplastics found at each station was different. The average concentration of microplastics found was 2.68 particles / m³. The value obtained was smaller than previous research conducted in Banyuurip waters, namely 7.11 particles / m³ (Auta et al., 2017), but higher than research conducted in the sea around Kupang and Rote, which was 0.051 particles / m³ (Hiwari et al., 2019).

The highest number of microplastics is found at station I with a concentration of 4.06 particles / m³ or 37.82%. Station I is Bonepitu Beach which is known as an area for aquaculture and fishing, the remains of fishery activities such as seaweed rope waste and fishing gear in the form of trawl and nets have the potential to be degraded into microplastics. In addition, the density of human settlements and the absence of official regulations regarding coastal cleanliness in this area is a source of microplastics due to household waste that is disposed of into the sea. After station I, the second highest number of microplastics was found at station II with a concentration of 3.86 particles / m³ or 36.01%. Station II is Pomnori beach which is a tourist

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Figure 2. Illustration of sampling in one station.

Figure 3. Comparison of microplastic concentrations for each station. Different letter symbols indicated statistically significant differences (P <0.05).
area and residential areas. Ponnori Beach is a natural tourism area that has regulations regarding environmental cleanliness but has not been well managed, residents and tourists are often found littering anywhere, polluting the coastal area. The high anthropogenic activity at stations I and II is believed to be a source of microplastics in the waters around the site. Oceanographic activities such as currents and tides of sea water are thought to be the cause of trapping of microplastics in this area (Veerasingam et al., 2017).

At station III found a microplastic concentration of 1.39 particles / m³ or 12.95%. Station III is Babana beach, which is the estuary area of the Temboe river, where along the river flow there are residential areas. The disposal of garbage into the river by local residents is thought to be a source of microplastic pollution that is carried by the current to the ocean. The low concentration of microplastics at station III compared to the concentrations of microplastics at stations I and II is due to the small number of settlements traversed along the Temboe river, thus indicating low plastic waste that can be disposed of into the river (Thevenon et al., 2014). In addition, river estuaries have strong currents ranging from 0.1 to 0.2 m / s and it is thought that it will be easier to transport microplastic particles in the water column to move to another place (Ayuningtyas et al., 2019). Station IV is Damaci beach, which is an area close to the pond. The microplastic concentration was found to be 1.42 particles / m³ or 13.21%. The low concentration of microplastics at station IV is influenced by the characteristics of the waters in the ponds which tend to be isolated so that microplastics from the remains of pond activity will continue to accumulate in the ponds (Ayuningtyas et al., 2019). Statistically, there is no significant difference between stations III and IV. The low concentration of microplastics found in these two locations is also thought to be due to current movement patterns (Victoria, 2017). At the time of sampling which resulted in microplastic particles moving southward with the current.

The microplastics found were 386 particles which were then identified in four groups, namely based on the shape, color, size and type of microplastic polymer.

3.1. Microplastic form

The identification results showed that there were four forms of microplastics found, namely granules, fibers, films and fragments (Figure 4). The microplastic concentration based on shape can be seen in Figure 5.

The most common form of microplastics is the form of fragments and the least is the form of film. Granular microplastics have a concentration of 0.11 particles / m³, a fiber form of 5.08 particles / m³, a film form of 0.06 particles / m³ and a fragment shape with a concentration of 5.47 particles / m³ of the number of microplastics found.

The results of statistical tests using one way ANOVA analysis showed that the microplastic concentration based on shape was significantly different (P <0.05). Differences were found between grain and fiber shape, grain and fragment shape, fiber and film shape and film and fragment shape.

The microplastics found consisted of four forms, namely granules, fibers, films and fragments. The most dominant form is fragments with a concentration of 5.47 particles / m³ or 51.04% which dominates in almost all stations. This is in line with the research of Ayuningtyas et al. (2019) in Banyuurip waters which found the microplastic particles had the highest number. Fragments are known as secondary microplastics because they come from larger plastic shards (Liu et al., 2019). According to Kumar et al. (2020) generally fragment type microplastics have a low density and tend to float in the water column and are more easily exposed. Fiber is the second largest type of microplastic particles after fragments with a concentration of 5.08 particles / m³ or 47.41%. Fiber is also a secondary microplastic whose existence comes from the degradation of fishing gear ropes and seaweed ropes at the sampling location (Barboza et al., 2018). The waters of South Larompang are mostly used as an area for catching and cultivating seaweed by the community. This could be the reason for the large amount of fiber found in the water column. According to Hoellein et al. (2019), aquaculture activities are one of the main contributors to microplastic fiber in waters. In addition, fiber can also come from degraded synthetic fabrics (Wang et al., 2017). Microplastic contamination of the fiber type originating from clothing fibers at the time of observation in the laboratory also has the potential to increase the number of microplastic particles. This is reinforced by the statement of Joesidawati (2019) which states that apart from ropes and fishing gear, fiber can also be produced from degraded clothing fibers.

Apart from fragments and fibers, other forms of microplastics have been found, namely films and granules. The film is a thin sheet with a very low density and has a white color (Wessel et al., 2016). Film has a lower density than fiber so that the presence of film is very dynamic in water (Wu et al., 2019). Films which are secondary microplastics are thought to come from pieces of plastic bags or food packaging from the surrounding environment. Microplastic with film form has the lowest concentration compared to other forms, namely 0.06 particles / m³ or 0.52%. This is presumably because the film has a low density so that its existence is erratic and easy to transform. Meanwhile, granules are microplastics that are not derived from larger plastics or are also called primary microplastics (Asmonate & Almroth, 2018). The presence of this type of microplastic is also found in small quantities, which have a concentration of 0.11 particles / m³ or 1.04%. Granular types of microplastics can be derived from body cleansing products such as toothpaste, scrubs and facial cleansers (Schwarz et al., 2019). The
low concentration of microplastics at this location is thought to be because granular type microplastics are generally produced by the factory industry (Wang et al., 2017), while in South Larompong District there are no factory industrial areas that have the potential to produce granular type microplastics. This is confirmed by the statement of Xanthos et al. (2017) stated that this granular type of microplastic is used as an ingredient in making cosmetics, soap and toothpaste which enter the waters through industrial waste.

3.2. Microplastic colors

There are six microplastic colors found, namely blue, brown, green, black, red and white (Figure 6). The concentration of microplastics based on color can be seen in Figure 7.

The most common microplastic colors are black and the least is green. The blue microplastic has a concentration of 1.03 particles / m$^3$, the brown color is 2.86 particles / m$^3$, the green color is 0.19 particles / m$^3$, the black color is 4.11 particles / m$^3$, the red color is 0.83 particles / m$^3$ and the white color is 1.69 particles / m$^3$.

The results of statistical tests using one way ANOVA analysis showed that the concentration of microplastics based on color was significantly different, there was a difference between green and black microplastics (P <0.05).

Based on the color identification results, there are six microplastic colors found, namely blue, brown, green, black, red and white. The most dominant color is black with a concentration of 4.11 particles / m$^3$ or 38.34%. Black color can indicate the amount of contaminants and organic particles that are absorbed in the microplastic (Hiwari et al., 2019). In addition, the black microplastic particles are thought to be due to the fragmentation of black plastic. The second most microplastic color found was brown with a concentration of 2.86 particles / m$^3$ or 26.68%. Brown microplastics are caused by fragmentation of brown plastics and organic materials that stick to the surface of the microplastics. Furthermore, white microplastics with a concentration of 1.69 particles / m$^3$ or 15.80% are thought to have originated from the degradation of white plastics and plastics that have been in the sea for years so they experience photodegradation. The next microplastic color is blue with a concentration of 1.03 particles / m$^3$ or 9.59%. The blue microplastic is thought to have come from the degradation of the seaweed cultivation rope and fishing gear. Light-colored microplastics such as red with a concentration of 0.83 particles / m$^3$ or 7.77% and green with a concentration of 0.19 particles / m$^3$ or 1.81% indicate that microplastic particles have not experienced discoloring or significant color changes (Solomon & Palanisami, 2016).

3.3. Microplastic size

The size of the microplastics found varies at each station. The range of microplastic sizes can be seen in Table 1.

![Figure 6. Color microplastics found: a). blue, b). brown, c). green, d). black, e). red and f). white.](image)

![Figure 7. Color concentration of microplastics. Different letter symbols indicated statistically significant differences (P <0.05).](image)

<table>
<thead>
<tr>
<th>Sampling station</th>
<th>Microplastic size range (mm)</th>
<th>Average size of microplastic (mm)</th>
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<tbody>
<tr>
<td>Station I</td>
<td>0.06-4.68</td>
<td>0.86</td>
</tr>
<tr>
<td>Station II</td>
<td>0.05-4.62</td>
<td>0.77</td>
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<tr>
<td>Station III</td>
<td>0.06-4.58</td>
<td>1.03</td>
</tr>
<tr>
<td>Station IV</td>
<td>0.05-4.77</td>
<td>1.32</td>
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</tbody>
</table>
The smallest microplastic size was 0.05 mm, while the largest microplastic size was 4.77 mm. Each microplastic size range for each station, namely station I has a size range of 0.06-4.68 mm with an average of 0.86 mm, station II has a size range of 0.05-4.62 mm with an average of 0.77 mm, station III has a size range of 0.06-4.58 mm with a mean of 1.03 mm and IV stations have a size range of 0.05-4.77 mm with a mean of 1.32 mm.

The microplastics that were found had a different size range for each station. The minimum size found was 0.05 mm and the maximum size was 4.77 mm. This is presumably because the microplastic has broken down into smaller (micro) particles. One of the causes of microplastic fragmentation from large particles to smaller particles is due to the presence of ultraviolet light and the oxidative properties of plastics and the hydrolytic properties of seawater (Weis, 2019).

3.4. Type of microplastic polymer

There are three forms of microplastic particles that were tested by FTIR. FTIR test results spectrum waves are fiber, film and fragments (Figure 8).

The white waves in the image represent the spectrum of the analyzed sample, while the red waves represent the spectrum of polymers in the software database. The results obtained were based on the analysis of polymer types, namely fiber microplastic and fragments which have HDPE (High Density Polyethylene) polymer type, while film microplastics have PVA (Polyvinyl alcohol) polymer type.

The FTIR test results showed that the type of polymer in the microplastic fiber and fragments was HDPE while the type of polymer in the microplastic film was PVA. HDPE and PVA are thought to come from anthropogenic activities of local residents, such as household waste and cultivation and fishing activities. This is because HDPE is a type of Polyethylene polymer which is widely used as a raw material for making plastic ropes, bags and bottles (Murphy & Quinn, 2018) while PVA is usually used as a coating on plastic products (Weis, 2019). Of the 42 microplastic research studies, Polyethylene was the most commonly found polymer, which was found in 33 studies and had a density of 0.917 - 0.965 g/cm³ while PVA had a density of 1.19 - 1.31 g/cm³ (Hidalgo-Ruz et al., 2012).

4. Conclusion

Based on the research results, it can be concluded that the waters of South Larompong have been contaminated with microplastics. The results of statistical tests using one-way ANOVA analysis showed that the concentrations of microplastics at the four stations were significantly different (P <0.05). The highest concentration was found on Bonepute beach, namely 4.06 particles / m³ and the lowest was found on Babana beach, namely 1.39 particles / m³. The average concentration of microplastics found was 2.68 particles / m³. There were 386 microplastic particles consisting of four shapes (granules, fibers, film and fragments) and six colors (blue, brown, green, black, red and white). The microplastic sizes found ranged from 0.05 - 4.77 mm. There are two types of polymer found, namely HDPE (High Density Polyethylene) and PVA (Polyvinyl alcohol). Future research should investigate whether differences in microplastic concentrations can be associated with pollution sources or environmental characteristics more specifically and also examine differences in microplastic concentrations based on the temporal distribution.

References


