Study of microplastic sediment abundance in Palu Bay, Central Sulawesi, Indonesia

Irawati M. Widiastuti, Novalina Serdiati, Akbar M. Tahya

Department of Aquaculture, Faculty of Animal Husbandry and Fisheries, Tadulako University, Palu, Central Sulawesi, Indonesia. Corresponding author: I. M. Widiastuti, irawatimei69@gmail.com

Abstract. Plastic waste is a complex problem in the waters of Palu Bay, Central Sulawesi, Indonesia. This study aims to analyze the abundance of microplastics in the sediments of the coastal area of Palu Bay. The survey method was used in this study by determining purposive sampling stations. Microplastic abundance was calculated as mean±standard error of mean. Data were analyzed for variance with the Tukey test, using the SPSS version 16.0. The types of microplastics found were film, fiber and fragments, which were dominated by films with sizes between 0.56-2.00 mm. The highest density and total microplastics were at station III. The sediment grains at all stations were dominated by coarse sand with the highest percentage at station III. Sediment in the coastal intertidal zone of Palu City has been contaminated by microplastics of anthropogenic sources of pollution (household activities, tourism and fisheries).
Key Words: anthropogenic, intertidal zone, pollution, valley, waste.

Introduction. Marine debris are represented by solid objects produced or processed by humans, directly or indirectly, intentionally or accidentally, discarded or left in the marine environment (Bamford 2013). Marine debris causes many problems, because it affects the aesthetic conditions of the sea, ecosystems, biota, and human health (NOAA 2016). According to Mato et al (2001), plastics are part of the most abundant waste found in the ocean because of their non degradable nature. Currently, global plastic production is estimated to have exceeded 300 million tonnes (Thompson et al 2009), and each year more than 10 million tonnes of plastic waste are dumped into the oceans (Löhr et al 2017). Jambeck et al (2015) state that Indonesia is the largest contributor to plastic pollutants to the world's oceans after China, with a scale of 0.48-1.29 million metric tons of plastic per year. This high percentage makes plastic waste one of the contaminants that can negatively impact not only on the environment, but also aquatic organisms. Along with urban development, population, industry, it is certain that the amount of plastic waste has increased. Microplastics in the sea are scattered on beaches, shallow waters and deep waters. Microplastics in marine waters can accumulate in large quantities in seawater and sediments (Hidalgo-Ruz et al 2012). The intertidal environment is an area that is very vulnerable to the buildup of microplastics due to anthropogenic pressures, such as marine and fisheries activities, coastal industrialization and population growth in coastal areas (Martin et al 2017).

Research on microplastic pollution in Indonesian waters has been carried out, including microplastics abundance in the sediments of the coastal area of Lamongan, East Java (Asadi et al 2019), the microplastics abundance in the sediments of tourist beaches in Badung Regency, Bali (Mauludy et al 2019), microplastic waste lines in the Savu Sea National Marine Conservation Area, East Nusa Tenggara (Purba et al 2019). The results showed that in the research locations, especially in coastal areas, there were many microplastics trapped in the sediment and microplastics carried by the currents. This shows that most of Indonesia's waters are polluted by microplastics.

Palu Bay is a water area located in Palu City, Central Sulawesi, as the center of coastal community activities (industry, tourism, culinary, hotels). This area is inseparable from the problem of waste, including plastic waste, which is found on the beach until it enters the 200 m zone around the coast. This condition is also supported by the large amount of trash carried by the river that enters the sea. The Environmental Service of Palu City, Central Sulawesi (2019) states that plastic bags dominate plastic waste in the city of Palu, the percentage of which reaches 30% of inorganic waste. Earthquakes, tsunamis and liquefaction cause increased waste in the area, including plastic waste. The existence of plastic waste puts pressure on the waters of Palu Bay and decreases the quality of the waters (Walalangi et al 2020; Sulistiawati et al 2020). The complexity of the problem related to the increase in plastic waste in the waters of Palu Bay after the earthquake and tsunami disaster from 2018 in Palu requires a special study because it has the potential to cause pollution, which is very dangerous for aquatic organisms and aquaculture activities. Limited information regarding the presence of microplastics in the waters of Palu Bay encourages this research to be carried out, so that it can be used as a rationale in determining proper waters management. Thus, the aim of this research was to analyze the abundance of microplastics in the sediments of the coastal area of Palu Bay, especially in the intertidal areas.

Material and Method

Description of study area. This research was conducted from May to August 2020 in the coastal area of Palu Bay, Central Sulawesi, Indonesia, which is a center for hotel, culinary, tourism and coastal community activities. Sampling stations were selected (I, II and III) based on the distance from the center of activities on land and sea, including tourism, culinary, fishery traffic and household activities (Table 1 and Figure 1).

Table 1

Coordinates and characteristics of the study area

Station	*Coordinates*		*Characteristics*
I	-0.822055º	119.883277º	Coastal area near tourism, household activities and disposal of sago waste
II	-0.819314º	119.880290º	Coastal area with little influence from land activities
III	-0.797940º	119.872555º	Coastal areas affected by household activities, fishing boats anchored and shrimp pond waste disposal streams

Sampling. Sediment samples were taken at each station using a transect measuring 50 x 50 cm^2, placed parallel to the coastline at a distance of 50 to 150 m, or depending on the length of the coastline. Sampling was carried out three times at the lowest tide. 9 samples were collected for sediment analysis and 9 samples for microplastic analysis. Sediment samples were taken at a depth of 0-10 cm and stored in closed plastic bags (Asadi et al 2019). Sediment samples were packed in ice boxes and brought to the laboratory within 48 h and stored at 20°C until further analysis was carried out (Kazmiruk et al 2018).

Microplastics analysis. Analysis of the abundance of microplastics in the sediment was carried out using a modified method from Masura et al (2015) and Laglbauer et al (2014). The sediment sample (150 g) was put into a beaker glass and heated at 90°C for 24 h in an oven. Samples were given 300 mL of saturated NaCl solution and homogenized using a magnetic stirrer. NaCl solution was used to separate microplastics (Kazmiruk et al 2018). The beaker glass containing the sample was covered with aluminum foil and left to stand for 24 h. The supernatant obtained was filtered with a 0.1 mm sieve, 20 mL of 0.05 M Fe (II) solution was added, and another 20 mL of 30% H_2O_2 solution was added. The mix was heated and homogenized at a temperature of 75°C on the hotplate (30 min). Samples that had no organic matter were filtered using a 0.3 mm and 5 mm sieve. The screening results were identified with a microscope. Microplastic abundance was calculated based on the number of microplastic particles per weight of dry sediment.

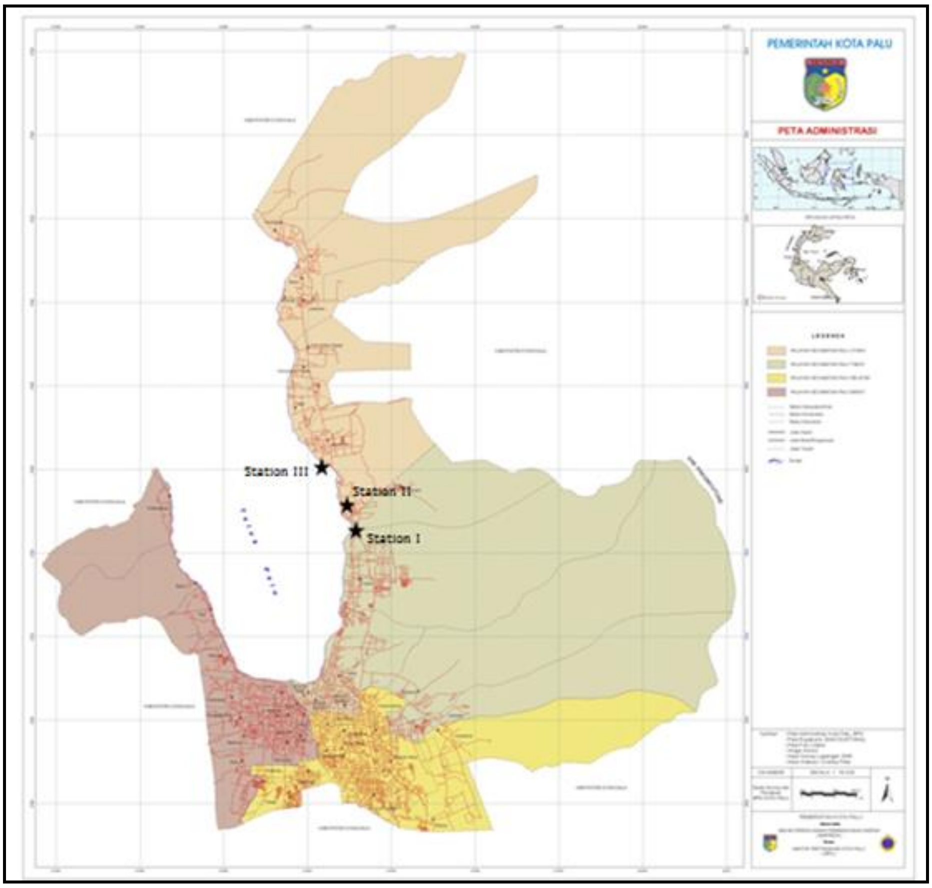

Figure 1. Study area on the coast of Palu Bay, Central Sulawesi, Indonesia.

Sediment grain size analysis. Sediment particle size was measured to determine the relationship between the deposition of microplastic particles and sediment type (Ling et al 2017). Analysis of sediment grains using the dry sieving method was carried out (McIntyre & Holme 1984; Triapriyasen et al 2016). The sediment samples were heated in an oven at 100°C, then sieved using a sieve shaker with 2 mm, 0.5 mm, 0.312 mm, 0.125 mm, and 63 μm sieves, then weighed. The sediment sample that passed the filter measuring 63 μm was combined with the sample size of 0.125 mm. After the grain size analysis method was completed, the results obtained were plotted and named according to the Wenworth classification.

Statistical analysis. Microplastic data was calculated as the mean ± standard error of mean (Asadi et al 2019) and analyzed with the Tukey test, using the SPSS version 16.0 software. Descriptive analysis was carried out by describing the abundance of microplastics based on the number of particles kg^{-1} and the size in each station (Hiwari et al 2019).

Results and Discussion

The abundance of types and sizes of microplastics. The results showed that microplastics were found in the sediments of all sampling stations. The types of microplastics in the sediments consist of film, fragments and fiber (Figure 2), with different percentages.

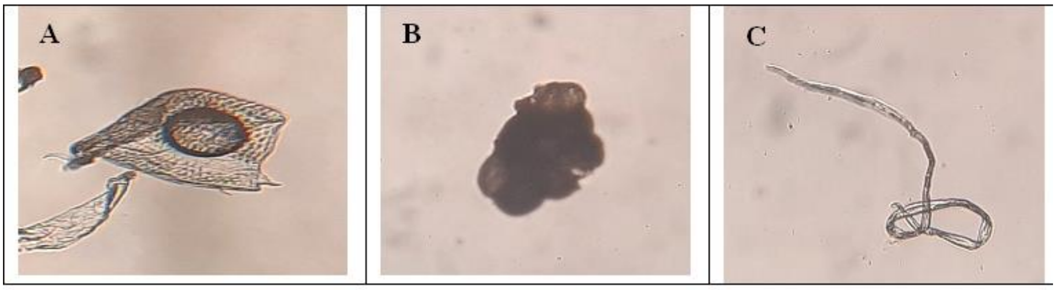

Figure 2. The types of microplastics found in sediments; A - film; B - fragment; C - fiber.

Film types dominated all sampling stations. The results showed an abundance pattern of microplastics in the sediments at the study site, namely film>fragments>fiber. The highest abundance of film microplastics was at station III (40.68±10.8 particle kg^{-1}). The results showed that there were differences between types and sizes of microplastics at all stations (α<0.05). Microplastics at the three stations were dominated by sizes between 0.56-2 mm (39.67±10.69 particle kg^{-1}). Figure 3 shows that, at station III, there are many microplastics with various sizes, but each microplastic size has a higher abundance compared to stations I and II.

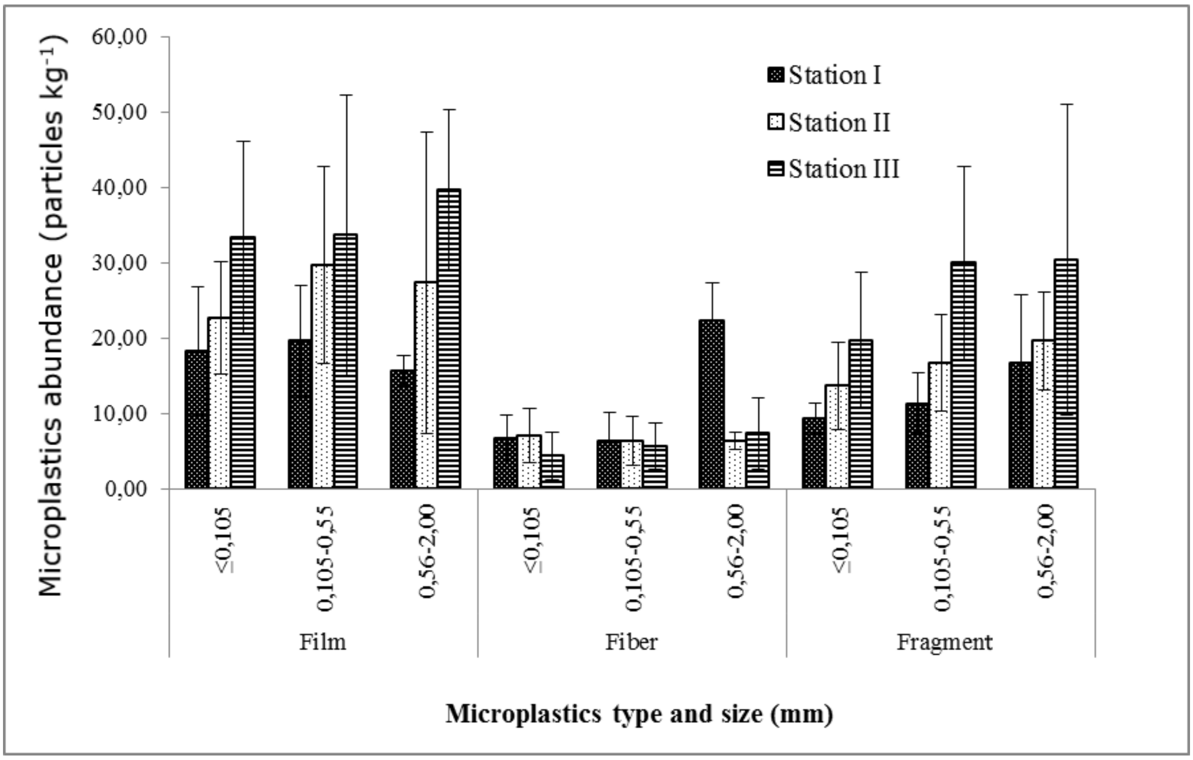

Figure 3. Abundance of microplastics in sediments based on size at stations I, II and III.

Total abundance of microplastics. The total abundance of microplastics indicates the total number of microplastics found in 1 kg of sediment. The results of the statistical analysis show the difference in the total abundance of microplastics at all stations (α<0.05). Figure 4 shows the highest total abundance of microplastics at station III.

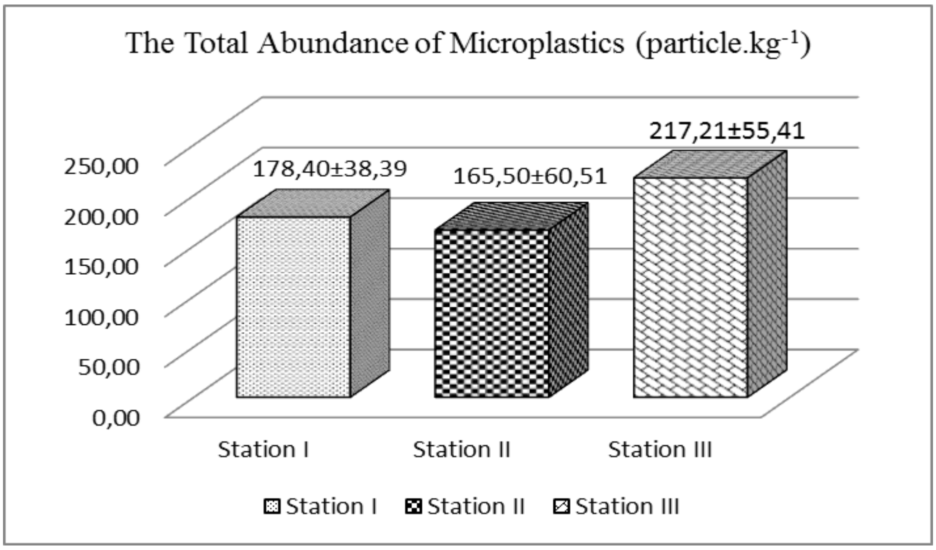

Figure 4. The total abundance of microplastics in the sediments at stations I, II and III.

Sediment grains. The results showed that the sediment at all stations consisted of gravel, granule, coarse sand, medium sand, fine sand and dust, according to the size of the sediment grains according to the Wentworth scale. The percentage of sediment grains at all stations varies, which is dominated by coarse sand (Figure 5). The highest percentage of coarse sand is at station III (34.04%±12.04).

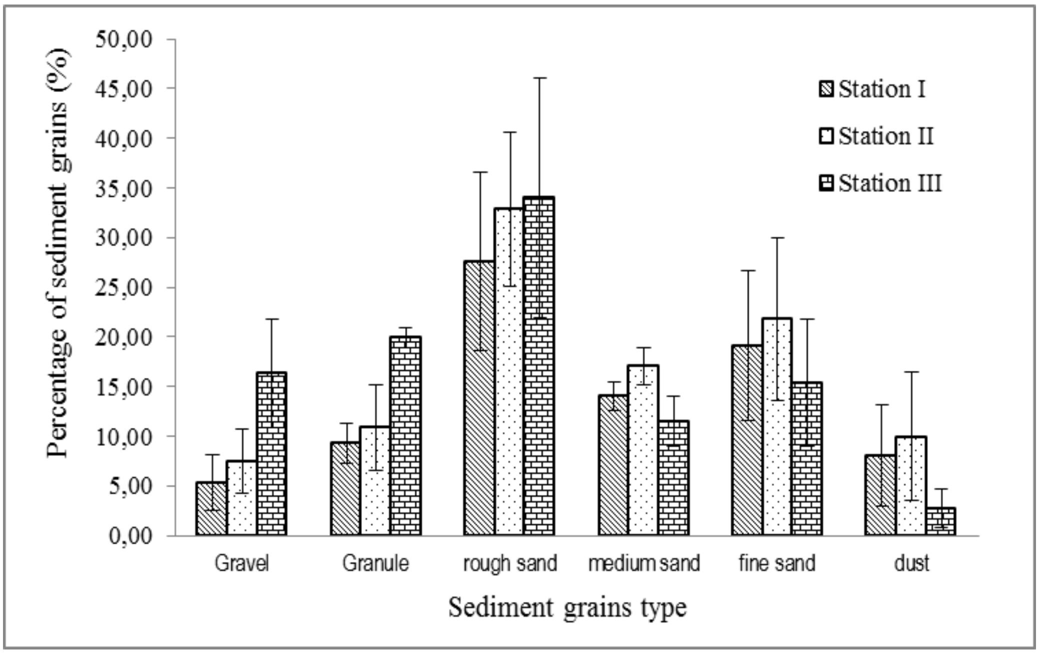

Figure 5. Percentage of sediment grains at station I, II and III.

The microplastics found in the study were the types of films, fragments and fibers. The highest abundance of film type microplastics occurred in all stations. This is related to the depth of sediment sampling. Therefore, the sediment surface is affected by sea water currents and the microplastic film type has the lowest density and the highest abundance. Low density microplastics are generally found on the surface of the water, while high density microplastics are found in the sediment (Andrady 2011; Reisser et al 2013; Zettler et al 2013; Jorissen 2014). This statement supports the results of the study, where sampling was carried out on the sediment surface to a depth of 10 cm.

Film type microplastics are plastic pieces that have a very thin layer in the form of a sheet with a low density (Dewi et al 2015; Di & Wang 2018). Many of these microplastics come from cuts and degradation of plastic bags and food packaging, which tend to be transparent (Law & Thompson 2014; Dewi et al 2015).

The second place in abundance is the fragment type. Fragments are fractions of larger plastics that come from pieces of plastic products with strong synthetic polymers (Cole et al 2011; Dewi et al 2015; Horton et al 2017). In addition, fragment type microplastics are the result of fragmentation from macro waste which is degraded due to UV radiation, sea water waves, oxidative materials from plastics and the hydrophilic properties of seawater (Andrady 2011; Hiwari et al 2019).

The lowest abundance of microplastic types in this study was fiber. The source of microplastic types of fiber can come from washing clothes, namely the residue of clothing threads and degraded plastic ropes (Crawford & Quinn 2017), fishing boat waste and fishing gear waste such as nets and fishing lines (Law & Thompson 2014).

The abundance of microplastics at station III was the highest, being related to the source of microplastics trapped in the sediment. Station III was represented by water partially covered by land, influenced by activities on land, such as households, fishing boats and fisheries. These characteristics cause waste to be trapped on the beach, including plastic waste.

The distribution and abundance patterns of microplastics in water bodies are influenced by rainfall (Eerkes-Medrano et al 2015), wind speed, water currents and tides (Gewert et al 2017). Other authors also stated that microplastic pollutants come from anthropogenic activities, including household waste, tourism activities, culinary activities, marine waste, and others (Law & Thompson 2014; Pham et al 2014; Gewert et al 2017).

The identified microplastics were ≤0.105 mm to 2 mm in size, dominated by sizes from 0.56 mm to 2 mm (rough sand). This indicates that the microplastics found have undergone a long degradation process. According to Claessens et al (2013), the cause of macro-sized plastic fragmentation to microplastics is due to the presence of ultraviolet radiation, the mechanical force of sea water waves, the oxidative properties of plastic, and the hydrolytic properties of sea water.

The pattern of abundance of microplastics in each region will differ according to the characteristics of the research location, therefore they cannot be compared (Qiu et al 2015). Factors that influence differences in the abundance of microplastics in the sediment include the type and size of the substrate, as well as the use of the sampling method in each study which causes different validation values (Qiu et al 2015). Mathalon & Hill (2014) and Alomar et al (2016) stated that the abundance values of microplastics varied at different sediment particle sizes.

Conclusions. The sediment in the coastal intertidal zone of Palu City, Central Sulawesi has been contaminated by microplastics, and the type of film measuring 0.56 mm to 2.00 mm has the highest abundance. The percentage of sediment grains at all stations varied, being dominated by coarse sand. The abundance of microplastic film and coarse sand sediment grains was the highest in station III.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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Authors:
Irawati Mei Widiastuti, Department of Aquaculture, Faculty of Animal Husbandry and Fisheries, Tadulako University, Jl. Soekarno Hatta km 9, 94118 Palu, Central Sulawesi, Indonesia, e-mail: irawatimei69@gmail.com
Novalina Serdiati, Department of Aquaculture, Faculty of Animal Husbandry and Fisheries, Tadulako University, Jl. Soekarno Hatta km 9, 94118 Palu, Central Sulawesi, Indonesia, e-mail: novalinaserdiati@untad.ac.id
Akbar Marzuki Tahya, Department of Aquaculture, Faculty of Animal Husbandry and Fisheries, Tadulako University, Jl. Soekarno Hatta km 9, 94118 Palu, Central Sulawesi, Indonesia, e-mail: amtahya@gmail.com

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