Preliminary Investigation on the Type and Distribution of Microplastics in the West Coast of Karimun Besar Island

B Amin*, M Galib and F Setiawan
Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Riau
Pekanbaru 28293 - Indonesia
*Corresponding Author: bintalamin@gmail.com / bintal.amin@lecturer.unri.ac.id

Abstract. High anthropogenic activity on the west coast of Karimun Besar Island contributes certain amount of wastes, especially plastics. Plastics will be degraded due to natural mechanism to smaller parts and known as microplastics. Small size and wide spread distribution has caused microplastics can be found widely in the waters and coastal areas. This study aims to determine type and abundance of microplastic in sediment on the west coast of Karimun Besar Island. Sampling of sediment for microplastic was determined based on hydrodynamic conditions by placing quadrat in the highest tidal boundary area. Sediment samples were collected in February 2019 using 4 inch PVC pipe from two different depth, i.e 0-10 and 10-20 cm. Separation of microplastic particles from sediments was carried out in Marine Chemistry Laboratory, Faculty of Fisheries and Marine Science University of Riau through several stages, namely (a) drying, (b) separation of densities and (c) sorting visually. The results of the study found only 3 types of microplastic, i.e. fragments, films and fibers. Microplastic abundance in sediments was found between 1976.67-2203.33 particles/kg of sediment with fibers being the dominant type. Fiber has the highest abundance in both depths followed by films and fragments. ANOVA and t-test analysis, showed that the quantity of microplastic between stations and between two different depths were not significantly different (p > 0.05).

Key words: Pollution, Microplastic, Sediment, Karimun, Riau Islands

1. Introduction
Waste is a problem for people all over the world, both waste originating from land and sea. One of the most common types of waste in land and sea areas is plastic waste [1]. Plastic waste pollution is one of the threats that is currently a concern in the world, especially in the territorial waters of the sea, this is because the volume of waste entering the sea waters every year is increasing. Plastic waste will experience degradation in the water that is broken down into small particles of plastic called microplastic. The wide spread of microplastic and the size and color that resembles food
(phytoplankton and zooplankton) results in the potential for microplastic to be consumed by various marine organisms. The smaller the microplastic particles, the more likely they are to be consumed by organisms in the waters [2].

Garbage in the coastal area is one of the complex problems faced by an area that is close to the beach, one of which is Karimun Island, which is an island located in Kepulauan Riau Province. As the population grows, many activities take place in the coastal area of Karimun Island, such as loading and unloading ships at ports, crude oil storage, fishing, mining, trading, tourism and household activities. Therefore, there is concern that waste disposal will occur in residential and coastal areas. The coastal water of Karimun Island is also being used by fishermen to catch fish and other marine organisms as a source of seafood. The phenomenon of marine debris in the form of microplastic will cause problems not only to marine organisms but also for human health. To date, there is no available information on microplastics in this region. Therefore, a preliminary study is needed to determine the presence and distribution of microplastic in sediments in the west coast of Karimun Island.

2. Research Methods
This research was conducted in April to June 2019 on the west coast of Karimun Island, Kepulauan Riau Province by taking samples from three stations. Station 1 located on Puakang Beach (0° 59'36.8 "NL 103° 25'22.7" EL), Station 2 on Pelawan Beach (1° 03'02.2 "NL 103° 18'46.1" EL) and Station 3 in the shipyard and stockpile industrial area (1° 04'26.3 "EL 103° 18'40.7" EL) as shown in Figure 1. Sample analysis was carried out at the Laboratory of Marine Chemistry at the Faculty of Fisheries and Marine Science, Universitas Riau.

![Map of research location and sampling station](image)

Figure 1. Map of research location and sampling station

The selection of locations for sediment sampling was determined based on hydrodynamic conditions of the coastal area by placing quadrat of 50x50 cm at the highest tidal boundary. The first quadrat was positioned along the coastline, whilst second and the third quadrats were about 10 m distance from one to another as suggested by [3] Sediment sampling was done by using a 4 inch PVC pipe from two different depths (0-10 and 10-20 cm) following procedure of [1]. Separation of microplastic particles from sediment was carried out in several stages (Figure 2), namely (a) drying, (b) density separation and (c) visual separation [4]. Sediment samples from each station were weighed as much as 100 grams each and then the samples were dried in an oven at 80°C to constant weight [5].
The dried sediments were then cooled in a dessicator, weighed as much as 50 grams and suspended with 150 ml concentrated and then stirred for 2 minutes \[6\]. The sediment was then allowed to settle for 24 hours until the suspension is clear \[6\]. About 1 ml of the suspension from the upper layer was taken and dropped into the Sedgewick Rafter Counting Cell count room \[5\]. Microplastic particles were visually sorted using an Olympus CX 23 microscope with a magnification of 10x10 and grouped into four types of microplastics, namely films, fibers, fragments, and pellets \[1\]. Based on the initial sample weight of 50 grams, the results of each analysis are converted to 1 kg so that the abundance of microplastic was counted as particles/kg dry sediment \[7, 4\]. One-factor ANOVA analysis was used to check the differences in the abundance of microplastic particles in sediment between stations while the independent sample t-test was used to check the differences in the number of microplastics at between the two depths. Data analysis was performed with the help of Microsoft Excel and SPSS 19 software.

3. Results and discussion

Karimun Island is included in a very strategic area for the development of economic and industrial activities in Sumatra Indonesia. It is located directly adjacent to two neighbouring countries, namely Malaysia and Singapore. The west coast of Karimun island is in the border area between Kepulauan Riau Province and Riau Province. Not only that, industries such as shipyards, crude oil storage and other anthropogenic activities are located around the west coast of Karimun Island. Therefore the west coast of Karimun Island is considered as a waste distribution channel (including microplastic) from the island’s anthropogenic activities.

The results of observations of microplastic abundance in sediments on the west coast of Karimun Island at two different depths ranged between 1976.67-2203.33 particles/kg of dry sediment (Table 1). Microplastic abundance obtained is greater than other reported studies conducted by \[6\] around the Belgian coast with a maximum abundance of 390 particles/kg of dry sediment, \[8\] in the Singapore mangrove ecosystem with a maximum abundance of 62.7 particles/kg of dry sediment and \[1\] at Muara Badak Kutai with abundance ranging from 41.38-193.92 particles/kg of dry sediment. However, higher abundance of microplastic were shown by study by \[7\] in China (8714 particles/kg) of dry sediment, \[9\] in Laguna Venice, Italy which has a microplastic abundance of 2175 particles/kg of dry sediment and in the Bay of Jakarta ranging from 18405-38790 particles/kg of dry sediment \[10\].
Table 1. Microplastic abundance (Mean± Std. Deviation)

| Station | Abundance (dry particles/kg sediment) |
|---------|--------------------------------------|
| 1       | 2203.33 ± 370.82                      |
| 2       | 2006.67 ± 310.01                      |
| 3       | 1976.67 ± 250.25                      |

The difference in abundance from each study is presumable due to the different characteristics of the study location [10]. The location of this study is a coastal area and is influenced by many anthropogenic activities such as human settlements, coastal tourism, and the shipbuilding and oil industry. Karimun Island is also one of the islands in Kepulauan Riau Province which borders directly with Singapore and Malaysia so that it can be assumed that the distribution of waste and microplastics also originates from these two countries carried by sea current and also by traffics of fishermen and commercial boats. Comparison of microplastic abundance between stations can be seen in Figure 3.

![Figure 3. Microplastic abundance at each station](image)

Although the abundance of microplastics at station 1 is higher than other stations, based on the results of Anova analysis, it was known that the number of microplastics between stations on the west coast of Karimun Island is not significantly different (p >0.05). So it can be assumed that the sampling location has the same oceanographic characteristics and does not have a different effect on the distribution of microplastics. [11] states that currents, tides and others are some of the factors causing microplastic distribution in waters. Current speed at the study site, which ranges from 0.40 to 0.50 m/sec, is one of the main factors in the distribution of microplastics in marine waters. According to [10,12] the low current velocity causes the movement of the macroplastic to slow down and build up so that it is strongly suspected that the plastic fragmentation process mostly occurs in that area.

Of the four common types of microplastics [10, 1, 6], there were only three types found in this study namely fragment, fiber and film types (Figure 4) while the type of pellet was not found (Tables 2). This is allegedly due to the absence of a plastic factory around the study site. According to [13] pellet type of microplastics are primary produced by factories as raw materials for making plastic products. Comparison of the overall abundance of microplastics between stations based on microplastic types can be seen in Figure 5.
Table 2. Abundance (Mean ± Std. Deviation) of microplastics based on its types

| Station | Microplastic type (particle/ml) | Fiber       | Film        | Fragment    |
|---------|--------------------------------|-------------|-------------|-------------|
| 1       | 1833.33 ± 250.33               | 283.33 ± 230.28 | 86.67 ± 48.44 |
| 2       | 1756.66 ± 298.64               | 193.33 ± 61.54 | 56.67 ± 32.04 |
| 3       | 1626.67 ± 233.12               | 273.33 ± 48.44 | 76.67 ± 46.33 |

Figure 4. Types of microplastics found on the west coast of Karimun Island

Figure 5. Overall microplastic abundance between stations based on microplastic types

Based on the results of the study, the type of fiber is the type that has the highest abundance compared to film and fragments. The abundance of fiber type of microplastic at station 1 > station 2 > station 3, whereas the types of fragment and film at station 1 > station 3 > station 2. The high abundance of fiber types on the west coast of Karimun Island is caused by community anthropogenic activities in urban areas, the activities of fishermen, loading and unloading ships, and household activities. Fiber type comes from monofilament fragmentation (single fiber) from fishing nets, ropes [14], synthesis cloth or clothing fibers [14, 8, 13, 15]. Microplastic with film type is resulted from fragmentation of plastic bags, plastic packaging and low density plastic [13]. According to [17] included in the low-density plastic or Low-Density Polyethylene (LDPE) is a chemical tank lining, general packaging plastics and gas and water pipes. Fragment type microplastics are the fewest types found at all stations. Fragment microplastics are sourced from the degradation of large plastic fragments [15,17], beverage bottles, discarded jars, mica map, gallon flakes, rice packs, fast food packaging and office waste [1].

Observation of microplastic types and abundance at sediment layer aims to see differences in abundance with respect to sedimentation at different depths. Microplastic abundance at sediment
depths of 0-10 cm has a higher abundance than in 10-20 cm depth (Table 3). This is confirmed by the statement of [1] which proves that the abundance of microplastics in the coastal areas of Muara Badak, Kutai Kartanegara Regency at a depth of 0-10 cm sediments tends to have higher abundances (69.3 - 90.12 particles/kg) in comparison to deeper layer of sediment. Continuous water runoff from land was assumed to be the cause of the high abundance of microplastics at sediment depths of 0-10 cm. Comparison of the mean abundance of microplastics in sediments at two different depths can be seen in Figure 6.

Table 3. Mean abundance microplastic in sediments at two different depths

| Station | Mean abundance of microplastic in sediment depth (particles/kg±Std. Dev.) |
|---------|-------------------------------------------------------------------------|
|         | 0-10 cm                                                                 |
| 1       | 2433.33 ± 344.87                                                       |
| 2       | 1946.67 ± 471.73                                                       |
| 3       | 2133.33 ± 261.02                                                       |
|         | 10-20 cm                                                                |
| 1       | 1973.33 ± 257.16                                                       |
| 2       | 2066.67 ± 83.27                                                        |
| 3       | 1820.00 ± 121.66                                                       |

Figure 6. Mean microplastic abundance in two different depth of sediments

Table 4 showed that fiber type microplastics most commonly found at both sediment depths. Abundance of microplastic particles are generally found higher in sediments rather than in water column. In certain cases microplastics with low density can also reach the sedimentary base by modifying its density through biofouling processes by prokaryotic, eukaryotic and invertebrate organisms that increase the density of the microplastics, causing low density microplastics to sink to the bottom of the water [18, 19, 20, 21, 22]. Comparison of microplastic abundance in sediments for each type at two different depths can be seen in Figure 7.
Table 4. Types and abundance (mean particles/kg of dry sediment ± Std. Deviation) microplastic in sediments at two different depths

| Types   | Station 1   | Station 2   | Station 3   |
|---------|-------------|-------------|-------------|
|         | 0-10 cm     | 10-20 cm    | 0-10 cm     | 10-20 cm    | 0-10 cm     | 10-20 cm    |
| Fiber   | 1926.67 ± 294.84 | 1740.00 ± 208.81 | 1733.33 ± 469.18 | 1780.00 ± 34.64 | 1753.33 ± 277.37 | 1500.00 ± 103.92 |
| Film    | 400.00 ± 301.99 | 166.67 ± 23.09 | 180.00 ± 72.11 | 206.67 ± 61.10 | 300.00 ± 52.92 | 246.67 ± 30.55 |
| Fragment | 106.67 ± 23.09 | 66.67 ± 64.29 | 33.33 ± 23.09 | 80.00 ± 20.00 | 80.00 ± 60.00 | 73.33 ± 41.63 |

Figure 7. Microplastic abundance for each type in sediments at two different depths

Independent sample t-test results indicated that the number of microplastics at two different depths was not significantly different (p > 0.05). This finding was in agreement with the same study conducted by [23] who also found that the abundance of microplastic was not significantly different between three different depths (0-30 cm) of sediment.

4. Conclusion

Microplastics found in sediments on the west coast of Karimun Island consist of three types, namely fragment, film and fiber with an average abundance between 1976.67-2203.33 particles/kg of dry sediment. Fiber is the most dominant type found at both depths (0-10 cm and 10-20 cm) followed by fragment and film types. The number of microplastics between stations and between depths was not significantly different (p> 0.05). Further study is needed to confirm this preliminary finding and to give more information on the danger of microplastic to the environment and human health.
References

[1] Dewi, I.S., A.A. Budiarsa dan I.R. Ritonga. 2015. Distribution of Microplastic at Sediment in the Muara Badak Subdistrict, Kutai Kartanegara Regency. Jurnal Depik. 4(3): 121-131

[2] Carson, H.S., M.S. Nerheim, K.A. Carroll dan M. Eriksen. 2013. The Plastic-Associated Microorganisms of the North Pacific Gyre. Marine Pollution Bulletin. 75: 126 –132

[3] Barasarathi, J., P. Agamuthu, C.U. Emenike dan S.H. Fauziah. 2014. Microplastic Abundance in Selected Mangrove Forest in Malaysia. Proceeding of the ASEAN Conference on Science and Technology, Institute of Biological Sciences Faculty of Science, University of Malaya, 50603 Kuala Lumpur Malaysia

[4] Hidalgo-Ruz, V., L. Gutow, R.C. Thompson dan M. Thiel. 2012. Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification. Environmental Science & Technology. 46(6): 3060-3075

[5] Hapitasari, D.N. 2016. Analisis Kandungan Mikroplastik Pada Pasir dan Ikan Demersal: Kakap (Lutjanus sp.) dan Kerapu (Epinephelus sp.) di Pantai Ancol, Palabuhanratu, dan Labuan. Skripsi. Departemen Biologi Fakultas Matematika dan Ilmu Pengetahuan Alam. Institut Pertanian Bogor. Bogor

[6] Claessens, M., S. De Meester, L. Van Landuyt, K. De Clerck dan C.R. Janssen. 2011. Occurrence and Distribution of Microplastic in Marine Sediments along the Belgian Coast. Marine Pollution Bulletin. 61: 2199-2204

[7] Qiu, Q., J. Peng, X. Yu, F. Chen, J. Wang dan F. Dong. 2015. Occurrence of Microplastics in the Coastal Marine Environment: First Observation on Sediment of China. Marine Pollution Bulletin. 98(1-2):274-280

[8] Nor, N.H.M. dan J.P. Obbard. 2014. Microplastic in Singapore’s Coastal Mangrove Ecosystem. Marine Pollution Bulletin. 79: 278-283

[9] Vinello, A., A. Boldrin, P. Guerrieri, V. Moschino, R. Rella, A. Sturaro dan L. Da Ros. 2013. Microplastic particles in sediments of Lagoon of Venice, Italy: First observations on occurrence, spatial patterns and identification. Estuarine, Coastal and Shelf Science. 130: 54-61

[10] Manalu, AA. 2017. Kelimpahan Mikroplastik di Teluk Jakarta. Tesis. Sekolah Pascasarjana. Institut Pertanian Bogor. Bogor

[11] Hardesty, B.D., J. Harari, A. Isobe, L. Lebreton, N. Maximenko, J. Potemra, E.V. Sebille, A.D. Vethaak dan C. Wilcox. 2017. Using Numerical Model Simulations to Improve the Understanding of Micro-plastic Distribution and Pathways in the Marine Environment. Frontiers in Marine Science. 4: 1-9

[12] Coppock, R.L., M. Cole, P.K. Lindeque, A.M. Queiros dan T.S. Galoway. 2017. A Small-Scale, Portable Method for Extracting Microplastics from Marine Sediments. Jurnal Environment Pollution. 230: 829-837
[13] Kingfisher, J. 2011. Micro-Plastic Debris Accumulation on Puget Sound Beaches. Washington: Port Townsend Marine Science Center. http://www.ptmsc.org/Science/plastic_project/ Summit20Final2Draft.pdf. diunduh pada tanggal 19 Oktober 2018

[14] TZW News. 2015. Microplastics in Fresh Water Resources. TZW news. Issue 4

[15] Browne, M.A., P. Crump, S.J. Niven, E. Teuten, A. Tonkin, T. Galloway dan R. Thompson. 2011. Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks. Environmental Science & Technology. 45(21): 9175-9179

[16] British Plastic Federation. 2019. Polyethylene (Low Density) LDPE, LLDPE. https://www.bpf.co.uk/plastipedia/polymers/ldpe.aspx. Diakses pada 7 Maret 2019

[17] Cole, M., P. Lindeque, C. Halsband dan T.S. Galloway. 2011. Microplastics as contaminants in the marine environment: A review. Marine Pollution Bulletin. 62: 2588–2597

[18] Andrady, A.L. 2011. Microplastics in the Marine Environment. Marine Pollution Bulletin. 62: 1596-1605

[19] Reisser, J., J. Shaw, C. Wilcox, B.D. Hardesty, M. Proietti, M. Thums dan C. Pattiaratchi. 2013. Marine plastic pollution in waters around Australia: characteristics, concentrations, and pathways. PLoS One. 8: 80466

[20] Zettler, E.R., T.J. Mincer dan L.A. Amaral-Zettler. 2013. Life in the “Plastisphere”: Microbial Communities on Plastic Marine Debris. Environmental Science & Technology. 47(13): 7137-7146

[21] Jorissen, F.J. 2014. Colonization by the benthic foraminifer Rosalina (Tretomphalus) concinna of Mediterranean drifting plastics. Marine litter in the Mediterranean and Black Seas. Monaco: CIESM Publisher. 87-95

[22] Manalu, A.A., S. Hariyadi dan Y. Wardiatno, 2017. Microplastics Abundance in Coastal Sediments of Jakarta Bay, Indonesia. AACL Bioflux. 10:1164-1173

[23] Hastuti, A.R., F. Yulianda dan Y. Wardiantno. 2014. Spatial Distribution of Marine Debris in Mangrove Ecosystem of Pantai Indah Kapuk, Jakarta. Bonorowo Wetlands. 4(2):94-107