The Occurrence and Distribution of Microplastic in Sediment of the Coastal Waters of Bengkalis Island Riau Province

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Abstract. The presence of microplastics, which was defined as small pieces of plastic less than 5 mm in size, in the aquatic environment has become a global concern these days. Once in the aquatic environment, microplastics might float in the water column or sink to the bottom sediment, depending on the particle density. This study was conducted in the coastal waters of Bengkalis Island in early 2020 with the aim to determine the occurrence and distribution of microplastics in sediment from six stations with suspected different sources of pollutant input. Sediment samples were taken using the PVC pipe at the depth of 0-10 cm, brought back to laboratory, observed the types and calculated their abundance. The results of the study showed that the highest abundance of microplastics was found at station 6 (83.33 and 26.67 particles/kg for fiber and film) and the lowest abundance was at stations 2 (30.00 particles/kg for fiber) and station 3 (10.00 particles/kg for films). The abundance of fiber type between stations was significantly different (p<0.05), but not for film type (p>0.05). The abundance of microplastics based on colour in each type showed that the highest abundance was in blue colour for fiber and white colour for film type. The abundance of microplastics in the northern part was found to be significantly (p<0.05) higher than in the southern part of Bengkalis Island which was assumed to be due to differences in oceanographic characteristics in both areas such as differences in the type and size of the sediment substrate.

1. Introduction
The increasing dependence of the community on using plastic in every activity without realizing it has been known to have long-term impacts on marine environment. Waste generated from all activities, either directly or indirectly, will be disposed of into the river and then flow into the sea. In the ocean, floating plastics will be degraded into small particles. It has been stated by [1] that almost all types of plastics will float or float in water bodies, causing the plastic to be torn apart and degraded by sunlight (photodegradation), oxidation, and mechanical abrasion to form plastic particles.

The presence of microplastics, which are defined as small pieces of plastic less than 5 mm in size [2, 3] in the aquatic environment has been reported elsewhere to become a global concern. Once in the aquatic environment, microplastics might float in the water column or sink to the bottom, depending on the particle density [2, 4]. Many studies have been conducted to analyze the presence of microplastics in the sediments [5, 6, 7, 8, 9]. As reported by [4], microplastics could sink to the bottom sediments as a result of biofouling, which can increase its density, the size and shape and also fluid density. Sediments have been considered to be major sinks of microplastics and the accumulation of microplastics in sediments can bring harm to marine and human life.

Bengkalis coastal waters has long been used as a fishing ground for both local fishermen. There is no available data so far on microplastics in sediment of Bengkalis island coastal waters. Therefore this study was conducted to determine the presence and distribution of microplastics in order to provide preliminary data which can be used in formulating management strategies for reducing their impacts in Bengkalis marine environment and in turn impact to human health through fish consumption.
2. Research methods

This research was conducted in the coastal waters of Bengkalis Island in early 2020 by taking samples from 6 stations representing the southern part of the island namely Ketam Putih (1°24'29.1"N 102°18'55.4"E), Bengkalis Kota (1°27'57.7"N 102°06'28.8"E) and Meskom (1°33'25.2"N 102°01'03.0"E) (St. 1, St. 2, and St. 3), and the northern part of the island which directly facing the Strait of Malacca, namely Jangkang (1°34'04.0"N 102°11'48.2"E), Selat Baru (1°33'48.1"N 102°14'46.0"E), and Pambang (1°29'56.9"N 102°28'27.4"E) (St. 4, St. 5, St. 6) as seen in Figure 1. Sample analysis was carried out at the Marine Chemistry Laboratory, Faculty of Fisheries and Marine Science, Universitas Riau.

Sediment samples were collected by using a 4-inch PVC pipe with a depth of 0-10 cm during low tide in the highest tide zone. The sediment samples were then put into labeled plastic bags and stored in a cool box. Separation of microplastic particles from sediment is carried out in several steps, namely (a) drying, (b) density separation, and (c) visual sorting [3]. The sediment samples from each station were weighed 100 grams each. Then the sample was dried in an oven at a temperature of 80°C until constant weight [10]. The dried sediment were cooled in a dessicator, then weighed 50 grams and suspended with concentrated NaCl (36.5 grams of NaCl for 100 ml Aquades and filtered with Vacuum Filtration) to 150 ml, then stirred for 2 minutes. The sediment was then allowed to settle for 24 hours until the sediment settled and the suspension was clear [11]. As much as 1 ml in the top layer of the suspension, was dropped into the Sedgewick Rafter Counting Cell counting space [10]. Microplastic particles were visually sorted using a microscope with a magnification of 10x10 and differentiated based on the type of microplastic (film, fiber, fragments and pellets), size and color. Based on the initial sample weight used as much as 50 grams, the results of each analysis were converted into 1 kg so that the abundance of microplastic is presented in units of particles/kg of dry sediment [12, 3].

3. Results and Discussion

3.1 Oceanographic parameters

In general, all oceanographic parameters measured in the present study were still in the range of tolerable levels for marine life and within the range of normal condition for coastal environment. The results of measurements of oceanographic parameters (salinity, temperature and current velocity) in the coastal waters of Bengkalis Island can be seen in Table 1.
Table 1. Results of water quality measurement during the study period

| Parameter          | Station 1     | Station 2     | Station 3     | Station 4     | Station 5     | Station 6     | Mean       |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|
| Salinity (‰)      | 29.00-30.00   | 31.00-32.00   | 31.50-30,43   | 31.00-30,50   | 31.00-32.50   | 31.02         |
| Temperature (°C)   | 30.00-30-31   | 31-32-31-33   | 31-32-31-33   | 31-33-32-35   | 33.00         |
| Current speed (m/s)| 0.38-0.42     | 0.30-0.43     | 0.33-0.39     | 0.45-1.15     | 1.05-1.59     | 0.78          |

The circulation of surface currents in Bengkalis coastal waters towards the Malacca Strait is influenced by surface currents in Southeast Asian waters that enter through the Malacca Strait. The tidal type in the Bengkalis estuary as part of the Malacca Strait is a mixed type leaning towards mixed tide, prevailing semidiurnal. In estuaries, tidal currents will move upstream at high tide and will come back outward at low tide. While the Malacca Strait tide type is semidiurnal tide. The flow of the Malacca Strait throughout the year moves from the southeast to the northwest (Figure 2). This indicates the magnitude of the influence of the water masses from the northern and southern parts of the strait.

Figure 2. Current direction in Bengkalis coastal areas (A. Direction during tide, B. Direction at low tide) and current direction in the Strait of Malacca (C. West monsoon (Northeast monsoon), D. East season (Southwest monsoon)

3.2 Microplastics in Sediments by Type
Apart from surface water, microplastics can also be found in sediments. The abundance of microplastics in the sediment samples usually higher than the abundance of microplastics in surface water. The influence of gravitational force and the amount of plastic density which is higher than the density of water causes the plastic to sink and accumulate in the sediment. Microplastic particles that are generally found in dominant sediments have a density greater than the density of water, while microplastics that have low density will be found on the surface of the water [13].

In this study, the microplastics found were in the form of fiber and film. Based on Table 2 and Figure 3, the highest abundance of microplastics was fiber in Station 5 (90.00±41.47) and film in Station 6 (26.67±20.66). The lowest was in Station 3 (30.00±24.50) for fiber and in Station 1 and 5 (6.67±10.33) for film. However, total abundance of microplastic was found in Station 6 (110.00) and the lowest in Station 2 and 3 (43.33) particles/kg.
Table 2. Abundance of microplastics in sediments by type

| Station | Fiber      | Film       | Total     |
|---------|------------|------------|-----------|
| 1       | 51.67±24.01| 6.67±10.33 | 58.33     |
| 2       | 33.33±16.33| 10.00±10.95| 43.33     |
| 3       | 30.00±24.50| 13.33±10.33| 43.33     |
| Mean South | 38.33±21.61| 10.00±10.53| 48.33     |
| 4       | 66.67±32.66| 10.00±10.95| 76.67     |
| 5       | 90.00±41.47| 6.67±10.33 | 96.67     |
| 6       | 83.33±32.04| 26.67±20.66| 110.00    |
| Mean North | 80.00±35.39| 14.45±13.98| 94.45     |
| Total mean | 59.16      | 12.23      | 71.39     |

Figure 3. Abundance of microplastics in the sediment by type

The high number of microplastics at station 6 compared to the abundance at other stations is probably due to differences in sediment types and anthropogenic activities and also hydrodynamic processes such as current direction in the area. According to [14], sediment texture affects the ability to capture microplastics. The softer the texture of a sediment, the greater the ability to capture microplastics, compared to the texture of sand and gravel. This is in accordance with the results of this research which shows that stations 4, 5 and 6 have a soft sedimentary texture because they are open coastal waters which have a high abundance of sediment due to the fast sedimentation process, therefore the amount of microplastics obtained is higher than with stations 1, 2 and 3. According to [15], the Bengkalis Strait waters have a sandy texture. Meanwhile, the northern part of Bengkalis Island waters has a softer substrate. This is influenced by the difference in higher waves and stronger currents in the Strait of Malacca than in Bengkalis Strait.

Based on statistical testing with the ANOVA test, it can be seen that the abundance of fiber-type microplastics is significantly different (p<0.05), and it is different from the abundance of film-type microplastics between stations which is not significantly different (p>0.05). The abundance of both types of microplastics between stations was contributed by varying amounts at each station, compared to the number of films found which were not too different between stations. This difference is probably due to the low density of film type compared to fiber, so that the film type will accumulate more easily. Film-type microplastics usually come from transparent plastics that have undergone degradation.
Figure 4 showed the higher abundance of both fiber and film types is in the northern part, this is due to differences in oceanographic characteristics of the sea between the northern (Malacca Strait) and southern parts (Bengkalis Strait). The results of statistical T-test between the southern part (Station I, II, III) and the northern part (Station IV, V, VI) showed a p value <0.05, which means that the microplastics in the southern and northern parts were significantly different (p<0.05). The influence of differences in the type and size of the sediment substrate on the presence of microplastics is thought to also affect the abundance of microplastics in the sediments, soft sediments will cause the microplastics to be trapped easily.

Based on Table 3, the abundance of microplastics is different in each place. The dominant type of microplastic found in this study in the form of fiber and is different from the results obtained in several studies. The difference in the abundance of microplastics is caused by the different characteristics of each location and the different activities that occur around the research location. On the island of Gili Labak (East Java), Pantai Wisata (Bali), Dongthing Lake (China) are waters with high fishing activities so that it will affect the abundance of microplastics in the form of fiber types, while film type are microplastics derived from plastic waste transparent which has degraded. Bengkalis is also high in fishing activities especially those in Station 5 and 6 which is known as fishing area.

Table 3. Comparison of microplastic in Bengkalis coastal waters with other studies

| Location                      | Mean abundance of microplastics in sediments (particles / kg) | Dominant type | Reference |
|-------------------------------|-------------------------------------------------------------|---------------|-----------|
| Pulau Bengkalis               | 71.39 ± 40.36                                               | Fiber         | This study|
| Pantai Indah Kapuk, Jakarta   | 204.1-2288                                                  | Film          | [16]      |
| Pulau Gili Labak, Jawa Timur | 13                                                          | Fiber         | [17]      |
| Teluk Jakarta                 | 18405-38790                                                 | Fragment      | [18]      |
| Muara Badak                   | 47.5 – 207.9                                                | Fragment      | [19]      |
| Pantai Wisata, Bali           | 90.7±59.1                                                   | Fiber         | [20]      |
| Dongthing Lake, China         | 445                                                         | Fiber         | [21]      |
| Tambak Lorok, Semarang        | 3,90                                                        | Film          | [22]      |
| Karimun, Kepri                | 1976.67-2203.33                                             | Fiber         | [9]       |
3.3 Microplastics in sediments based on color

The color of microplastics found in sediments will affect the potential for microplastic ingestion by benthic organisms. The abundance of microplastics based on color in each type has various patterns, with the highest abundance value for each station on blue fiber, while for film type the highest abundance is in white color (Table 4).

**Table 4. Abundance of microplastics in sediments by color**

| Station | Fiber | Film |
|---------|-------|------|
|         | Black | White | Blue  | Black | White | Blue  |
| 1       | 10.00±10.95 | 13.33±16.33 | 43.33±15.06 | 6.67±10.33 | 0.00±0.00 | 0.00±0.00 |
| 2       | 0.00±0.00 | 6.67±10.33 | 26.67±10.33 | 0.00±0.00 | 10.00±10.95 | 0.00±0.00 |
| 3       | 0.00±0.00 | 0.00±0.00 | 33.33±16.33 | 0.00±0.00 | 13.33±10.33 | 0.00±0.00 |
| 4       | 0.00±0.00 | 23.33±23.38 | 43.33±26.58 | 3.33±8.17 | 3.33±8.17 | 3.33±8.17 |
| 5       | 23.33±26.58 | 30.00±35.21 | 36.67±26.58 | 6.67±10.33 | 0.00±0.00 | 0.00±0.00 |
| 6       | 6.67±10.33 | 33.33±16.33 | 43.33±19.66 | 6.67±10.33 | 16.67±15.06 | 3.33±8.17 |

Based on statistical tests using non-parametric Kruskal-Wallis test, it showed that the abundance of microplastics based on color was not significantly different (p>0.05). From the research that has been done at each station, it shows that the fiber has a different color compared to the type of film. This can be due to the fact that fiber is the dominant type found at each station, so that the color of the fibers found would be more diverse.

The difference in the color of microplastics in the waters is influenced by the source, for example, the blue color of the fiber is an artificial color resulting from anthropogenic activities [23]. The color can also be the original color or the color of degradation due to the removal of the original color due to photochemical processes or other processes.

3.4 Microplastics in sediments based on size

The results of observations on the abundance of microplastics that have been carried out on the sediment found 6 size groups, where the highest abundance of microplastics is in group 5 (100-500 µm) at stations 6 with an abundance of 56.67 ± 19.66 particles/kg.

**Table 5. Abundance of microplastics in sediments by size**

| Station | Size of microplastics (µm) |
|---------|---------------------------|
|         | 20-40 | 40-60 | 60-80 | 80-100 | 100-500 | 500-1000 |
| 1       | 0.00±0.00 | 3.33±8.17 | 6.67±10.33 | 16.67±15.06 | 30.00±10.95 | 16.67±15.06 |
| 2       | 0.00±0.00 | 3.33±8.17 | 6.67±10.33 | 6.67±10.33 | 26.67±20.67 | 0.00±0.00 |
| 3       | 3.33±8.17 | 3.33±8.17 | 6.67±10.33 | 6.67±10.33 | 23.33±8.17 | 0.00±0.00 |
| 4       | 3.33±8.17 | 10.00±16.73 | 6.67±10.33 | 20.00±12.65 | 36.67±15.06 | 0.00±0.00 |
| 5       | 0.00±0.00 | 3.33±8.17 | 6.67±10.33 | 20.00±12.65 | 33.33±16.33 | 33.33±16.33 |
| 6       | 6.67±10.33 | 0.00±0.00 | 10.00±16.73 | 33.33±16.33 | 56.67±19.66 | 6.67±10.33 |

The results of non-parametric statistical tests showed that the group size of 20-80 µm was not significantly different (p>0.05). Meanwhile, microplastics with the size of 80-1000 µm for each group were significantly different in size (p<0.05). It can also be seen in Table 5 that the abundance of microplastics in the group sizes 1, 2 and 3 were not too varied or almost in the same range compared to groups of sizes 4, 5 and 6 which have wider range of abundance values. The small size of the microplastic in the sediment is influenced by the density of the microplastic material and also other factors such as currents and waves. Plastics that have accumulated for a long time in the waters will get entangled and stick to the sediments.
4. Conclusions and Recommendations

The abundance of microplastic in sediment of Bengkalis coastal waters was found in range of 48.33–94.45 particles/kg with an average of 71.39 particles/kg. Fiber type of microplastic found was dominated by blue color, whilst film type by white color and they were mostly in the size of 100-500 µm. Further study is needed to get clearer picture whether the microplastics in Bengkalis coastal waters originated from community activities on land or from consigned waste brought ashore by the seawater current.

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