Distribution and abundance of macroplastic at Musi estuary, South Sumatera, Indonesia

G Almiza¹ and M P Patria¹,²,*

¹Marine Science Program, Faculty of Mathematics and Natural Science, Universitas Indonesia, Depok 16424, Indonesia
²Department of Biology, Faculty of Mathematics and Natural Science, Universitas Indonesia, Depok 16424, Indonesia

*mpatria@gmail.com

Abstract. Musi River in the upstream and estuary is used for fisheries, transportation, industry, and settlement. These activities have potential to produce plastic waste with various types and sizes, one of them is macroplastic (2.5-100 cm). This study aims to determine the distribution and abundance of macroplastic in the upstream and estuary of the Musi River. This study used a purposive sampling method with 6 stations, 2 stations in the upstream and 4 stations in the estuary. Macroplastic sampling used transect quadrants then sample is cleaned and dried, counted, identified and weighed for each type. And for macroplastic coverage by taking photos of each transect quadrant, then calculate the percent of coverage using the Point Intercept Transect (PIT) method. The results of this study indicate that the macroplastic abundance in the upstream and estuary of the Musi River ranges from 5-32 items/m² with an average weight of 27.82 – 126.89 gr/m². Macroplastic types are dominated by plastics fragments, food wrappers, other jugs/containers, bags/films, and cups, while macroplastic coverage is dominated by bags/films.

1. Introduction
Musi River located in South Sumatra Province, is one of the longest rivers in Sumatra Island with a length of ± 700 km [1]. And The Musi Estuary is located in the Banyuasin which has the population around the estuary of the Musi River is 60,776. The high number of population through by the Musi River and those in the estuary, as well as high activities (fisheries, transportation, industry, and settlement), this cause plastic waste by various types and sizes [2]. Some research about marine debris showed that 50-90% of sea was dominated by plastic [3]. Jasmin et al. [4] said that Jakarta, capital city of Indonesia, is one of the highest contamination level waters in the world includes pollution of debris. Moreover, Roman et al. [5], said that 99% of all seabird species are predicted to ingest marine debris by 2050 in Australia.

According to Kadir et al. [6] plastic waste was one type of marine debris that was currently becoming an environmental problem on the coast. The plastic pollution can be found on every beach, which has ecological, economical and human impacts [2]. Musi estuary which has a lot of waste from the mainland has the potential to get a negative impact. While the Musi estuary ecosystem is one of the assets of the South Sumatra Province which is important because it has several functions including as a mangrove.
habitat, has a high fishery production of 29,468.11 tons, and also support the economic life of the peoples around the estuary who mostly work as fishermen.

Based on the problems mentioned above, this study was aimed to determine the distribution and abundance of macroplastics that are located in the upstream and estuary of the Musi River. In addition, this study also compares macroplastics approaching water and those approaching land, and calculates the percentage of macroplastic coverage with modifications from the PIT method. Previously [7] had conducted a similar study that examined macro debris (not only plastic) that was on the surface of the water (floating) upstream and the mouth of the Musi River. So this research is important to provide information about the condition in the estuary and upstream of Musi River and also showed activities that could affect the distribution of macroplastics. The results of this study can be used as guidelines for local community and government in waste management and the formulation of policies on sustainable coastal development, so the surrounding community can live with a better environment.

2. Methods

This study uses a purposive sampling method and sampling was conducted in April 2019 at Musi Estuary, South Sumatra Province. The location of the study consisted of 6 stations, 2 stations in the upstream (Station 1&2) and 4 stations in the estuary (Station 3, 4, 5, &6). Station 1 and 2 located in Palembang city, Station 3 and 5 around Makarti Village, Station 6 in front of Sungsang Village, Station 4 near mangrove and also far from settlement (Figure 1). Each station was taken 5 points and each point was installed with two transect quadrants (1x1 m²) namely one approaching water and one approaching land (Figure 2).

The method of collecting and classifying macroplastics are collecting macroplastics in a quadrant area, drying and cleaning debris from water and sand, classifying and identifying waste according to Lippiatt et al. [2], then weigh for each type of macroplastic using micro scales. The classification of waste included plastic fragments, food wrappers, beverage bottles, other jugs / containers, bottles & container caps, cigarette filters, disposable cigarette lighters, bags, plastic ropes & small net pieces, cups, straws, personal care products, cigar tips, buoys & floats, fishing lines & lures, ballons, pellets.

Meanwhile, to find out the percent of macroplastic coverage using the modification of the Point Intercept Transect (PIT) method [8]. Each quadrant was taken a photo from above and then the transect point was determined by macroplastic type, then calculated the percentage by dividing the sum of each component by the total of components, and then multiplied by 100%.

Figure 1. Map of research locations at Musi estuary, South Sumatra.
3. Results and discussion

3.1. Macroplastic abundance

The results of sampling at the upstream and estuary of the Musi River there are differences in abundance and weight of macroplastic between stations which can be seen in Table 1.

Table 1. Macroplastic abundance in the upstream and estuary of the Musi river.

| Station | Approaching water | Approaching land | Average | Approaching water | Approaching land | Average |
|---------|-------------------|------------------|---------|-------------------|------------------|---------|
| 1       | 18                | 16               | 17      | 89.68             | 108.05           | 98.87   |
| 2       | 10                | 11               | 10      | 34.89             | 28.94            | 31.91   |
| 3       | 6                 | 4                | 5       | 18.86             | 95.98            | 57.42   |
| 4       | 7                 | 7                | 7       | 21.45             | 34.20            | 27.82   |
| 5       | 13                | 10               | 11      | 68.74             | 79.92            | 74.33   |
| 6       | 35                | 28               | 32      | 118.76            | 135.02           | 126.89  |

Macroplastic abundance found in the upstream and estuary of the Musi River ranges from 5-32 items/m² with an average weight of 27.82-126.89 gr/m², it was difference from research by Cauwenberghe et al. [9] which not only counts abundance macroplastic but all marine debris with amounts ranging from 4.41-10.03 items/m² and weight ranging between 66.3-374.66 gr/m² per sampling period. While the results of research in Belgian continental shelf by Maherlsa et al. [10] showed that the number and weight of macrodebris found was dominated by plastic types with 95% of the total debris obtained.

The highest of macroplastic abundance is 32 items/m², was found at station 6, followed by the highest amount of macroplastic weight of 126.89 gr/m². Station 6 is near to a fishermen village; the village is included in the coastal sub-district namely Banyuasin II which has 6 villages with a population of 2018 recorded 31,518 people. With a high population and has not had a landfills, and in the village where floating houses and stand tightly along the riverbanks, so people can easily dispose of their debris directly into the waters rather than going to a landfill so waste plastic is easily carried by the flow.

Research by Hill and Wilkinson [7] also showed the highest abundance of floating macrodebris founded is plastic in the Sungasang Village with a total of 33 items. In Figures 2 and 3 we can see the abundance and weight of macroplastic based on approaching water and approaching land:

![Figure 2. Diagrams of Macroplastic Abundance per quadrant in the upstream and estuary of the Musi River, South Sumatra.](image-url)
In Figure 2 it can be seen that the macroplastic abundance that approaching water was more than that approaching land even though the difference was not too large, this was probably be influenced by water conditions at the time of sampling. While for the macroplastic weight approaching water is lighter than that approaching land (Figure 3) because the type of plastic with a lighter mass will be easily carried by water flow and the density of plastic with a heavy mass will be left on land. Figure 3 show that Station 3 has a quite large difference in the amount of macroplastic weight between approaching water and approaching land compared to other stations because station 3 has a muddy substrate, sampling after rain, and contour ramps so that waste is easily carried by water currents. In addition, seen from the type of macroplastic found at station 3 that the type of microplastic that dominates is a school bag with a fairly heavy weight (382.91 grams). Whereas the macroplastic types found at the approaching point of water are only mild types (0.10-26.75 grams / item) such as food packaging and plastic bags. This is confirmed by the statement from Schwarz et al. [11] that the factors that influence the amount of oceanic waste reaching an area are salinity, temperature, vertical movement particle, type of sediment, density, surface area, and size of plastic.

### 3.2. Macroplastic type

The results of this study show that the macroplastic types found in the upstream and estuary of the Musi River there are 12 types of 17 types [11], there were plastic fragments, food wrappers, beverage bottles, other jugs / containers, bottles & container caps, cigarettes / cigarette filters, disposable cigarette lighters, bags (films), plastic ropes & small net pieces, cups, straws, and personal care products. While the 5 types that’s not found are cigar tips, buoys & floats, fishing lines & lures, ballons, pellets. In the picture below can be seen that the type of plastic that dominates in each station:
Figure 4. Macroplastic types in the upstream and estuary of the Musi River (Plastic fragments (1); Food wrappers (2); Beverage bottles (3); Other jugs/containers (4); Bottle & container caps (5); Cigarettes/cigarette filters (6); Disposable cigarette lighters (7); Bags/film (8); Plastic rope & small net pieces (9); Cups (10); Straws (11); Personal care products (12)).

The results of this study show that the type of plastic that dominates at the observation station is plastics fragments (5.84–15.24%), food wrappers (9.26–32.97%), other jugs/containers (4.44–13.65%), then the type of bags/films (7.91–14.13%) and cups (3.33–31.38%). The number of macroplastics of the five types was allegedly due to the proximity of the observation station to the source of waste, which is in the settlement and this type of plastic is very light so it is easy to carry by water. Greenpeace in 2018 researcher plastic waste in 3 locations including Kuk Cituis Beach (Tangerang), Pandansari Beach (Yogyakarta), and Mertasari Beach (Bali) with the findings, first food and beverage packaging, then used packaging for body care products, and products household needs with the amount of debris collected from the three locations is 10,594 packages, while the source of the plastic waste is thought to come from the surrounding community and from distant places then carried away.

3.3. Macroplastic coverage

In this research were made regarding macroplastic coverage at the Musi River Estuary. Macroplastic coverage in the upstream and estuary of the Musi River consists of 10 types of macroplastic i.e. plastic fragments, food wrappers, beverage bottles, other jugs/containers, bottle & containers caps, bags (film), plastic rope & small net pieces, cups, straws, and personal care products. The most common coverage is the type of bags (film) found in 5 stations of 6 stations because this type has a lightweight form that is easy to fly and drift away, so its spread is quite wide. Research by Cauwenbergh et al. [9] in Labuange Beach found thick and thin plastic bags dominate marine waste.

The highest macroplastic coverage of the type of bags (film) is 12.5% at station 1, because the sampling location is near from the settlement, and there is a market on the riverbank, so it is very easy for the surrounding community to throw debris directly into the waters. According to Calcar van and van Emmmerik [12], the composition of plastics in the river varies greatly and depends on the local plastic waste management infrastructure. Research by Purba et al. [13] at west coast of Pangandaran show that the result of debris is originally comes from settlements, tourists, traders, and fishermen.
4. Conclusion
Macroplastic abundance found in the upstream and mouth of the Musi River ranges from 5-32 items/m² with an average weight of 27.82 - 126.89 gr/m². Macroplastic abundance that approaching water is more than that approaching land, even though the difference is not too large. Macroplastic types that dominate are plastics fragments, food wrappers, other jugs/containers, bags/films, and cups. The highest macroplastic coverage is the type of bags (film). The results of this study can be used as guidelines for local governments in waste management and the formulation of policies on sustainable coastal development, so that the surrounding community can live with a better environment. The results of this study are expected to be used as a reference for subsequent studies on macroplastics, because this study did not collect macroplastics based on tides.

Acknowledgment
This research was supported by The Grant of International Publications for Universitas Indonesia Students Final Project (PITTA B) No NKB-0642/UN2.R3.1/HKP.05.00/2019 to M P Patria.

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