

Impacts of macro - and microplastic on macrozoobenthos abundance in intertidal zone

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Abstract. Plastics pollution in coastal areas is one of the topics that have received more attention over the past few years. The intertidal zone is a waters area that is directly affected by contamination of plastic waste from land and sea. The purpose of this study was to analyze the types and abundance of plastic waste in the intertidal zone and its impact on macrozoobenthos abundance. This research was conducted at Pesisir Desa Jaring Halus in February-April 2017. Macrozoobenthos and macro - micro plastic were collected by using quadratic transect. Sediments were collected with a core, to a depth of 30 cm. Microplastic and macroplastic abundances were analyzed using separation of sediment density and hand sorting. The dominant micro plastic types were film (52.30%), fiber (24.88%), fragments (22.74%), followed by pellets (0.1%). The total number of microplastics were 326,33 items and macro plastic were 308 items. Macroplastic abundance is positively correlated with microplastic (0.765). The abundance of macrozoobenthos is negatively correlated with microplastic abundance (-0.368) and with macro plastic abundance (-0.633). The management strategies were suggested clean up marine debris, decrease plastic using and built up the station of debris processing.

1. Introduction

Development is an inseparable part of human civilization. Life without development activity is a setback in human civilization. Often developments such as industrial and agricultural factories do not pay attention to the environmental aspect, thus destroying nature. The plastics industry is one of the industries that continue to grow along with the high use of plastics in society [1, 2]. The low public awareness of plastic waste management becomes one of the causes of the amount of plastic waste in the environment, especially in coastal waters.

Marine debris is a persistent solid, manufactured or processed by humans, directly or indirectly, intentionally or unintentionally, disposed of or abandoned in the marine environment. Type of marine waste including plastic, cloth, foam, styrofoam, glass, ceramics, metal, paper, rubber, and wood [3, 4]. The size category is used to classify marine debris, ie mega debris (> 100 mm), macro debris (> 20-100 mm), me so debris (> 5-20 mm), and micro debris (0.3-5 mm) [1, 3, 4].

Various problems arise due to marine debris, such as reduced coastal beauty, minimis of various diseases, affecting food web, and reduced productivity of fish caught [3] [5] [6] [7] [8]. The potential effects of marine waste chemically tend to increase the size of plastic particles (micro plastic)



decreases, while the physical effect increases with the increase in macro debris size [3]. Makrodebris provides physical impact such as closing the surface of the sediment and disrupting the movement of aquatic organisms [6, 9, 10] and can prevent the growth of mangrove seeds [9]. Macroplastic can also be a host for the growth of invasive species especially those attached to the substrate [6, 8].

Microplastic potentially threatens more seriously than large plastic materials as organisms that inhabit lower tropical levels, such as planktons that have particles susceptible to microplastic digestion processes, as a result, can affect high-level tropical organisms through bioaccumulation [6, 10, 11]. Microplastic is consumed by marine organisms when one of the micro plastic particles resembles food [8, 12, 13, 14].

The presence of macro and micro plastic in the environment especially the aquatic environment can have an impact on the existence of organisms. [7, 8] Macrozoobenthos is one of the several organisms that receive pressure from plastic waste contamination. Macrozoobenthos is often used to predict the imbalance of the physical, chemical, and biological environments of waters [15]. The polluted waters will affect the viability of macrozoobenthos organisms because macro-zoobenthos is a water biota that is easily affected by the presence of pollutants.

The phenomenon of marine waste in the form of plastic causes unrest in the community with the presence of garbage that has polluted coastal and marine areas, including the Village Jaring Halus Langkat. In addition, the absence of preliminary information about micro plastic in this region is one of the constraints to manage the potential of fisheries and marine-based environmentally friendly. Based on this, it is necessary to conduct a study to find out the macro plastic and microplastic distribution and its impact on macrozoobenthos in the Jaring Halus Village.

2. Materials and Methods

2.1. Study site

The research was conducted in Jaring Halus Village, Langkat Regency, North Sumatra Province, Indonesia. Data were collected from February to April 2017. The tools used were Global Position System (GPS), meter, sample bottle, tool box, core, 1m × 1m board, filter, shovel, digital camera, and stationery.

2.2. Method of macroplastic survey

The macrodebric samples (> 20mm) were collected with transects (1 × 1 m) from each substation with the highest tidal boundaries and the lowest tidal boundaries divided into 3 sections [9]. The macrodebric composition is grouped into plastics, fabrics, foams, styrofoam, glass, metal, rubber, and wood. Samples are collected into sacks and labeled. The items (to further explain the flakes) in each macrodebric group are collected macroplastic, dried, calculated, and weighed. The parameters taken include the number of items (item m⁻²) and weight (g m⁻²) [16].

2.3. Method of microplastic survey

Sediment sampling (1L) was performed with core based on three stratified depths (0-30 cm). The core placement is performed on three sections (top, middle and bottom edge) at the substations at the highest tide and lows. The separation of microplastic particles (0.045-5 mm) from the sediments was carried out by several stages, namely (a) drying, (b) volume reduction, (c) separation of density, (d) filtration, and (e) visual sorting. Drying was done with 105 ° C oven for 72 hours. The dry-sediment volume reduction step was performed by filtration (5 mm in size) [17]. The density separation step is carried out by mixing the dry sediment sample (1 kg) and the saturated NaCl (3L) solution and the mixture are stirred for 2 minutes [18].

Floating plastics are polystyrene, polyethylene, and polypropylene. The filtration stage is carried out by filtering the supernatant (size 45 µm). Microplastic particles are visualized using a monocular microscope and grouped into four types, namely film, fiber, fragments, and pellets. The parameters taken were density (particle kg-1 dry sediment) [17].

2.4. Sampling of macrozoobenthos

A sampling of macrozoobenthos was done on the same plot/transect as macro and micro plastic retrieval. The macrozoobenthos samples were taken with the same transect as macro and micro plastic retrieval. Taking macro-zoobenthos is taken on each transect plot with a depth of 30 cm. All the substrate on the plot is removed with a shovel, then stored in a plastic bag for separation. The separation between macrozoobenthos and substrate is done in the field with the help of water and filter. Samples of macrozoobenthos that have been separated from the substrate are fed into a 70% alcohol-treated sample bottle to be identified in the laboratory.

2.5. Data analysis

The macroplastic abundance is calculated by the formula [4]:

$$K = \frac{n}{w \times l} \quad (1)$$

Information:

K = Macroplastic Abundance

n = Number of Macroplastic (item / m³)

w = Width of Sampling Area

l = Length of Sampling Area

Microplastic abundance is calculated by the formula [4]:

$$K = \frac{n}{a \times h} \quad (2)$$

Information:

K = Microplastic Abundance

N = Number of Microplastic (item / m³)

A = Sample Area of Sampling

H = Depth of Sampling

Biota Density of macrozoobenthos with formula [15]:

$$K = \frac{n_i}{A} \quad (3)$$

Information :

K = Density

ni = Number of individuals of a type

A = Area Area

Correlation analysis between macro and microplastic to macrozoobenthos using Pearson Correlation SPSS.

3. Results and Discussions

3.1. Macroplastic

The total number of macro plastic collected from 3 stations divided into 27 observation plots were 308 items with total weight is 3689.87 gr. The highest macro plastic density found in Station 2 ranged between 18.33-190.33 species / m² with weights ranging from 246.33 to 2103 gr. The lowest density found in Station 3 ranged from 3.33 to 11.67 species / m² with weights ranging from 13.46 to 117.67 gr. Density and macro plastic weights can be seen in table 1.

Plastics is one of the most common types of waste found in various places both on land and in waters. The common marine waste category found in the Coastal Village of Jaring Halus is the macroplastic ie plastic waste with the size larger than 5 mm as many as 308 items (table 1). Hastuti (2014) found macro plastic density in Mangrove Ecosystem Pantai Indah Kapuk Jakarta as many as 6079 species. Some research results abroad have found that marine debris is dominated by macro plastic at 48% in Cassina Beach, Brazil [19], 67.6% Northeast Coast Brazil [20], 89% in Bootless Bay,

Papua New Guinea [21], 91 % In Midway, North Pacific [22], 68% in Monterey Beach, USA [23], 77% in Kaohsiung, Taiwan [24], 45.2% to 95% Eastern Mediterranean and Black Seas [25] and 60.5 to 80% In Gulf Coast of Guinea of Ghana [26]. The macro plastic proportion is dominant because its density is lower than glass, metal, and water density so it is easily transportable [1, 7, 25].

The highest macro plastic densities found at station 2 (near community settlements) ranged from 18.33 to 190.33 species m^{-2} . This is allegedly due to community activity that contributes most macro plastic compared to Station 1 (faced with Malacca Strait). Macroplastic density is influenced by the amount of marine debris carried from the sea such as fishing and shipping activities in the Malacca Strait and Station 3 (opposite the Ular River) where the macro plastic density is influenced by the amount of waste carried by the river. It also indicates that the station distance to the main pollutant source (settlement) effects macro plastic density.

Table 1. Abundance and Macroplastic Weights

| Station | Macroplastic Abundance (item/ m^2) | | | Total | Macroplastic Weight (gr) | | | Total |
|---------|--|--------|--------|-------|-----------------------------|--------|--------|---------|
| | Plot 1 | Plot 2 | Plot 3 | | Plot 1 | Plot 2 | Plot 3 | |
| 1 | 32.67 | 9.67 | 5 | 47 | 393 | 115.67 | 65.67 | 574 |
| 2 | 190.33 | 31.67 | 18.33 | 240 | 2203 | 508 | 246.33 | 2957 |
| 3 | 11.67 | 5.33 | 3.33 | 20 | 113.67 | 31.08 | 13.46 | 158 |
| Total | 234.67 | 46.67 | 26.67 | 308 | 2709.67 | 654.75 | 325.46 | 3689.87 |

The result of Kruskal-Wallis test shows that macro plastic density between stations is significantly different with p value = 0.005. Mann-Whitney test results show that the macro plastic density of Station 1 is significantly different from Station 2 with p value = 0.031 and not significantly different from Station 3 with p value = 0.147. The station's macro plastic density 2 differs significantly from station 3 with p = 0.02. The result of Kruskal-Wallis test shows that macro plastic density between plot is significantly different with p = 0.004. Mann-Whitney test results showed that the macro plastic density of Plot 1 was significantly different from Plot 2 with p = 0.031 and significantly different from Plot 3 with p = 0.003. The macro plastic density of Plot 2 is not significantly different from Plot 3 with p = 0.63.

The result of Kruskal-Wallis test shows that macro plastic density between station plot of observation is not significantly different with p = 0.857. This indicates that the highest tidal distance and lows at each station do not affect macro plastic density. This is in accordance with the results of other studies [27] which obtain macro debris density in the mangrove ecosystem of Pantai Indah Kapuk is not significantly different between stations and indicates that the station distance from the sea does not affect macro debris density.

3.2. Microplastic

The highest micro plastic density is found in plot 1 of all observation stations which is the highest tidal boundary. Density decreases in the lowest tide and lows. This indicates that in the intertidal zone, the micro plastic decreases in density as the distance to the sea increases. Prove similarly that the micro plastic density in tidal zones at the highest tidal boundary is higher than at the lowest tidal boundary and there is a real difference between the two [14, 28]. The zone at the lowest tide is a very dynamic zone, deposition can occur constantly. Sediments in the upper layers in this zone are susceptible to runoff and become suspended again.

Microplastic film type is the highest type found in all observation plots. The film comes from fragmentation of plastic waste such as packets of food and soft drinks, plastic bags and plastic wrapping fish commonly used in fishing activities. The film also has the lowest density so it is easily distributed by the presence of currents and tides [18, 28]. Other research results on the Belgian Coast [28] gained micro plastic fiber type flavors (59%). While in Muara Badak, East Kalimantan [29] the

highest abundance of microplastic fragments (58.97%) was found. This indicates the type of micro plastic depends on the macro plastic and the source of the plastic pollutant. The high fiber on the Belgian coast is due to the point of location close to the fishery port area. Fiber is derived from the activity of catching while the fragment is the result of a piece of plastic product with a very strong synthesis polymer [28].

Table 2. The Percentage of Density and Average Density of Microplastic

| Station | Percentage of Microplastic Abundance | | | | Abundance |
|---------|--------------------------------------|-------|----------|--------|----------------------|
| | Film | Fiber | Fragment | Pellet | Average (item/kg) |
| 1 | 60.27 | 22.30 | 17.47 | 0 | 89 |
| 2 | 45.07 | 30.03 | 24.63 | 0.3 | 173.33 |
| 3 | 51.57 | 22.30 | 26.13 | 0 | 64 |
| Total | 52.30 | 24.88 | 22.74 | 0.1 | 326.33 |

The result of Kruskal-Wallis test shows that the density of micro plastic between stations is significantly different with the value of $p = 0$. This indicates that there is one station with a microplastic density that is significantly different from other stations. Mann-Whitney test results show that the stationary micro plastic density station 1 is significantly different from station 2 with p value = 0.031 and not significantly different from station 3 with $p = 0.094$. The station's micro plastic density station 2 differs significantly from station 3 with $p = 0.002$. This proves that the micro plastic density will be higher with reduced distance from the main pollutant source and with increasing distance from the main pollutant source the density is more affected by other pollutant sources such as river and sea currents [30]. The result of Kruskal-Wallis test showed that the micro plastic density between the observed plots was not significantly different with the value of $p = 0.984$.

3.3. Macrozoobenthos

The highest density of macrozoobenthos was found in station 3 with a density of 61 ind m^{-2} . In Plot 1 Station 2 no macro-zoobenthos is found in any depth stratification. The average density of macrozoobenthos at the observation point can be seen in Table 3.

The result of analysis using Pearson correlation shows the relationship between macro-zoobenthos density with macro plastic equal to 0.633 with the level of strong and micro plastic relationship of 0.386 with the low level of relationship. Macroplastic density with microplastic of 0.756 with strong relationship level. This suggests that macro plastic density affects macro-zoobenthos density. Increased macro plastic density causes decreased macro-zoobenthos density. The macro plastic can close the surface of the sediment and disrupt the movement of aquatic organisms [6, 9].

Table 3. The Average Density of Macrozoobenthos

| Stations | Macrozoobenthos Density | | | | | | | | | Total |
|----------|-------------------------|------|------|------|------|------|------|------|------|-------|
| | 1* | | | 2* | | | 3* | | | |
| | 10** | 20** | 30** | 10** | 20** | 30** | 10** | 20** | 30** | |
| 1 | 6 | 4 | 4 | 5 | 3 | 3 | 4 | 3 | 4 | 36 |
| 2 | 0 | 0 | 0 | 3 | 2 | 3 | 3 | 5 | 3 | 18 |
| 3 | 2 | 13 | 3 | 19 | 5 | 2 | 9 | 4 | 3 | 61 |
| Total | 8 | 17 | 7 | 26 | 10 | 8 | 16 | 12 | 10 | 115 |

*Plot | **Depth

Microplastic density has a low correlation to macro-zoobenthos it is presumably because micro plastic affects the digestive system of macrozoobenthos which can lead to accumulation in

macrobenthos digestive organs [7, 8, 18, 30]. Macroplastic density with Microplastic of 0.756 with strong relationship level. This indicates that the micro plastic density is affected macro plastic. The higher the macro plastic density will lead to increased micro plastic density. Microplasticity results from macro plastic fragmentation [1, 7, 28, 29, 31].

4. Conclusions

An increase in the number of macroplastic densities has led to a decrease in macrozoobenthos density. Macroplastic density has a strong negative impact on macrozoobenthos density while microplastic density has a low negative impact on macrozoobenthos density. Increased macroplastic density leads to an increase in microplastic density.

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