Corrigendum: The amount and type of plastics in the Baiya Beach after the Palu Bay tsunami (2021 J. Phys.: Conf. Ser. 1763 012072)

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Description of corrigendum:

Page 3:
In the Table 1 where the decimal format before still using comma, the following text in the table appears:

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In the Figure 6, the following figure appears:

![Figure 6](image-url)

**Figure 6.** An overview of the flow velocity before and during the sampling at Baiya beach, a) before the sampling (H-0), b) during the sampling (H-24).

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Page 5:
In the Figure 7, the following figure appears:

![Figure 7](image)

**Figure 7.** An overview of the wave and wind profile on the beach, a) wave profile, b) wind profile.

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![Figure 7](image)

**Figure 7.** An overview of the wave and wind profile on the beach, a) wave profile, b) wind profile.
The amount and type of plastics in the Baiya Beach after the Palu Bay tsunami

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Abstract. Plastic is a material that cannot naturally be decomposed. The increase in the amount of marine litter is influenced by currents, winds, tides and tsunamis at certain locations. The purpose of this study was to study marine litter on the Baiya beach, Palu Bay using a rapid beach survey from the pre and post tsunami time of Palu Bay on September 28 2018. The results of monitoring the amount of marine litter before the tsunami at Baiya Beach in 2017 contained 4 meso litter materials with 10 litter types. There were 6 materials of macro litter, found 24 litter types. After the Palu Bay Tsunami in 2018, monitoring in 2019 found 9 materials of meso and macro with 31 litter types. Monitoring in 2020 found 9 meso litter materials with 19 litter types. There were 9 materials of macro, found 29 litter types. The plastic increase in marine litter on Baiya beach during monitoring was dominated by PL24 (other plastics) and the tsunami incident increased the litter type of plastic.

1. Introduction

Palu Bay is an area that was affected by an earthquake with a magnitude of 7.4 and tsunami on September 28, 2018. This incident has left various problems both in the land area and the coastal area of Palu Bay. One of the problems caused is the large amount of waste that is scattered in several areas on the coast of Palu Bay. Moreover, the number of people living around the coastal areas, the development inland areas and riverbanks after the earthquake and tsunami were increased markedly. This, of course, will have a negative impact on the Palu Bay coastal area.

The factors that cause damage to coastal areas is the increase in the amount of waste caused by the increase and spread of the population who are mostly located on the banks of the water such as rivers and seas, and there is still a community paradigm that the sea can still be considered to be able to manage waste [1]. Open dumping causes surface water contamination due to leachate mismanagement and uncontrolled flow of material. The visible impact affecting ocean coasts globally is marine debris, which is mainly caused by plastic waste [2],[3]. The movement of water masses or currents can cause an increase in the volume of waste at certain locations [4]. Description of the physical mechanisms that the movement of water masses are highly influenced by winds and tides allow for describing pollutant monitoring and biological/ecological applications [5]. With the conditions of increasing litter in marine waters, accompanied by strong winds blowing from the sea, it will carry waste to the coast. Meanwhile,
the movement of water masses from land or from the upstream part of the river is strongly influenced by the volume of water upstream which can be caused by increased rainfall. This condition will directly correlate positively with the increase in the waste in the coastal area [6], presumably this also occurs in the Palu bay area.

The results of monitoring the amount of waste before and after the tsunami in one area in Palu Bay, to be precise at Baiya Beach in 2017, reported that there were 6 macro materials with 24 litter types. This litter is dominated by wood, plastic and other materials (diapers, cleaning tools) [7]. Based on this, a study on marine debris monitoring was carried out on Baiya Beach, Palu Bay from the pre and post tsunami time.

2. Site study and methods
The rapid beach survey/beach litter assessment is based on the guidelines for monitoring Marine Litters released by The Pollution and Coastal Damage Control Directorate, Environment and Forestry Ministry in 2017. Post-tsunami data were carried out on the Baiya beach, Baiya Village, Tawaeli District, which was carried out on August 7, 2019 and August 12, 2020. The pre-tsunami conditions were based on the survey data on November 16, 2017 [7].

![Sampling Location at Beach Baiya Palu Bay.](image1)

![Transect Lines, 10 Transect Plots (blue :Size 5 x 5 m) and Sub Transects (Red : Size of Plot 1x1m²) a total of 5 Plots determined randomly.](image2)

2.1 Field sampling
The coastal biophysics include sandy beach types and ramps and the tidal range is about 10 m, the height of the ± 2 m tidal interval with the coastal slope of 15.80° [7]. The transect line at the Baiya beach location, the size of the transect made is 100 m x 30 m (tide and low). Sampling locations and line transect sketches made at each monitoring location are shown in Figures 2, while the coordinates of each transect and sub transect are shown in Table 1.
Table 1. Coordinates of each transect and sub transect

| No | Kode Titik | Latitude   | Longitude   |
|----|------------|------------|-------------|
| A  | High Tide  |            |             |
| 1  | A1 point   | -0.721992  | 119.858920  |
| 2  | A2 point   | -0.721956  | 119.858902  |
| 3  | E1 point   | -0.722679  | 119.858354  |
| 4  | E2P point  | -0.722661  | 119.858328  |
| B  | Low Tide   |            |             |
| 1  | A2 point   | -0.721956  | 119.858902  |
| 2  | A3 point   | -0.721920  | 119.858866  |
| 3  | E2 point   | -0.722661  | 119.858328  |
| 4  | E2 point   | -0.722634  | 119.858274  |

2.2 Current, wave and wind profiles
The map of ocean currents, wave and wind profiles before and after sampling in 2020 was taken from the following website in the “WAVE MEAN PERIOD” section: https://peta-maritim.bmkg.go.id/ofsf#/.

2.3 Data analysis
The marine litter collection was carried out in situ based on the litter classification of 9 material classes and 77 litter types [8]. After the samples in the form of marine litter have been collected, it was followed by grouping the samples into categories in the form of plastic (PL), Foamed Plastic (FP), Cloth (CL), Glass & Ceramic (GC), Metal (ME), Paper & Cardboard (PC), Rubber (RB), Wood (WD) and Other (OT). The number and weight of each type were calculated on each transect. This study also focused on the amount of material found in plastics and materials containing plastics such as foamed plastic, rubber and other materials from the rapid beach survey.

3. Results and discussion
3.1 Categories marine litter
The litter size obtained in the monitoring area (tidal and low tide areas) was macro litter (> 2.5 cm in size) and meso litter (0.5 cm-2.5 cm). The litter percentage based on the amount of both meso and macro litter on the Baiya beach was dominated by plastic (Figure 3), based on the composition percentage a year after the tsunami in 2019 was dominated by plastic and in 2020 the percentage of plastic composition increases.

The litter dominated by plastic (macro and meso), respectively 51.70% and 34.23% (Figure 4.)

Figure 3. Category and size of litter in count total number
Figure 4. Categories and size of litter in % total number

Figure 5. Litter type count in %
3.2 Current, wave and wind profiles analysis

**Figure 6.** An overview of the flow velocity before and during the sampling at Baiya beach, a) before the sampling (H-0), b) during the sampling (H-24).

**Figure 7.** An overview of the wave and wind profile on the beach, a) wave profile, b) wind profile.
3.3 Categories and size of litter in items/m²
Categories and size of litter found at Baiya Beach are listed in Table 2.

| Material     | Litter Type                        | Categories and size of litter in items/m² | 2017  | 2019  | 2020  |
|--------------|-----------------------------------|------------------------------------------|-------|-------|-------|
|              |                                   |                                          | Macro | Meso  | Macro | Meso  | Macro | Meso  |
| PLASTIC      | PL01 Bottle caps & lids           |                                          | 0.08  | 0     | 0.32  | 0     | 0.04  | 0.24  | 0     |
|              | PL02 Bottles < 2 L                |                                          | 0.24  | 0     | 1.44  | 0.24  | 0.28  | 0.36  | 0     |
|              | PL03 Bottles, drums, jerrycans & buckets > 2 L |                                          | 0.08  | 0     | 0.32  | 0     | 0.04  | 0     | 0     |
|              | PL04 Knives, forks, spoons, straws, stirrers, (cutlery) |                                          | 0.28  | 0     | 0.72  | 0.48  | 0.28  | 0.16  | 0     |
|              | PL05 Drink package rings, six-pack rings, ring carriers |                                          | 0.4   | 0.12  | 1.16  | 0.08  | 2.24  | 0.24  | 0     |
|              | PL06 Food containers (fast food, cups, lunch boxes & similar) |                                          | 2.36  | 0.28  | 0.96  | 0     | 0.2   | 0     | 0     |
|              | PL07 Plastic bags (opaque & clear) |                                          | 2.52  | 0.2   | 0.76  | 0.08  | 1.68  | 0.44  | 0     |
|              | PL08 Toys & party poppers         |                                          | 0     | 0     | 0.64  | 0.04  | 0     | 0.04  | 0     |
|              | PL11 Cigarettes, butts & filters  |                                          | 0.04  | 0     | 0     | 0.28  | 0.08  | 0     | 0     |
|              | PL16 Sheet ing (tarpaulin or other woven plastic bags, palette wrap) |                                          | 0.32  | 0.08  | 0     | 0     | 0.04  | 0     | 0     |
|              | PL17 Fishing gear (lures, traps & pots) |                                          | 0     | 0     | 0     | 0     | 0.16  | 0.08  | 0     |
|              | PL18 Monofilament line            |                                          | 0.04  | 0     | 0     | 0     | 0     | 0.04  | 0.08  |
|              | PL19 Rope                         |                                          | 0     | 0     | 0.56  | 0.32  | 0     | 0.04  | 0.24  |
|              | PL21 Strapping                    |                                          | 0.16  | 0     | 0.28  | 0.08  | 0     | 0.04  | 0     |
|              | PL22 Fibreglass fragments         |                                          | 0.04  | 0     | 0     | 0     | 0     | 0     | 0     |
|              | PL23 Resin pellets                |                                          | 0     | 0     | 0     | 0     | 0     | 0     | 0.04  |
|              | PL24 Other (specify): other plastic |                                          | 3.08  | 0.28  | 2.04  | 3.76  | 0.64  | 0.72  | 0     |
| FOAMED PLASTIC | FP01 Foam sponge                 |                                          | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
|              | FP02 Foamed plastic              |                                          | 0     | 0     | 0     | 0     | 0     | 0     | 0.12  |
|              | FP03 Foam buoys                  |                                          | 0     | 0     | 0.12  | 0     | 0     | 0     | 0.04  |
|              | FP04 Foam (insulation & packaging) |                                          | 0     | 0.04  | 0     | 0     | 0.12  | 0.16  | 0     |
|              | FP05 Other (specify): other Foamed Plastic |                                          | 0     | 0     | 0.12  | 0.04  | 0     | 0     | 0     |
| RUBBER       | RB02 Footwear (flip-flops)        |                                          | 0.00  | 0.00  | 0.08  | 0.04  | 0.04  | 0.08  | 0     |
|              | RB05 Inner-tubes and rubber sheet |                                          | 0.12  | 0.00  | 0.00  | 0.08  | 0.04  | 0.04  | 0.00  |
|              | RB08 Other (specify): other rubber |                                          | 0.00  | 0.00  | 0.16  | 0.04  | 0.00  | 0.00  | 0.00  |
| OTHER        | OT01 Paraffin or wax             |                                          | 0.40  | 0.00  | 0.20  | 0.00  | 0.00  | 0.00  | 0.00  |
|              | OT02 Sanitary (nappies, cotton buds, tampon applicators, toothbrushes) |                                          | 0.00  | 0.00  | 0.16  | 0.00  | 1.12  | 0.12  | 0.12  |
|              | OT03 Appliances & Electronics    |                                          | 0.00  | 0.00  | 0.00  | 0.12  | 0.00  | 0.00  | 0.00  |
|              | OT05 Other (specify): gunny sack  |                                          | 0.20  | 0.00  | 0.08  | 0.20  | 0.04  | 0.00  | 0.00  |

3.4 Discussion
The impact of the earthquake and tsunami on September 28, 2018 in Palu and surrounding resulted in a serious damage and a number of casualties. Based on plotting and spatial analysis of shake map and fault data into the administrative boundaries of Central Sulawesi Province and Palu City, the sampling location is a low-prone location with a minimum damage intensity of V MMI, and the higher the intensity of the damage towards Palu City [9].

The movement of accumulated litter along the course of the tsunami with the impact can vary depending on the type of marine litter. The Japan Tsunami Marine Debris (JTMD) noted that items observed such as abandoned nets, plastic tarpaulins and small boats could destroy sensitive ecosystems and the species on which they live. Fishing line, nets, ropes and other can entangle, injure and even drown many species of wildlife by encircling or ensnaring them. Debris like bottle caps, matches and plastic scraps is also harmful to wildlife. This debris can behave like and resemble food for animals. Once ingested, these materials can cause starvation and/or choking [6]. Artificial marine debris is generally dominated by relatively small plastic items (exclusion fishing nets), tsunami debris includes large items, such as wood and other construction materials from damaged houses as well as large objects, such as boats and floating jetty [10].

In contrast to the spread of marine debris and marine life across the sea from Japan to North America and the Hawaiian Islands due to the 2011 Japan Earthquake and Tsunami [11], to the coast of North
America close to 100,000 items in the four-year study period [12], the distribution of marine litter that accumulated on Baiya Beach during the tsunami originated from the Makassar Strait and northern parts the coast of the Palu Bay mouth. Baiya Beach is strongly influenced by the characteristics of the waters of Palu Bay, which are protected marine waters and changes in water currents from the Makassar Strait. The current profile in August 2020 show that the current velocity in the waters of Baiya Beach before the sampling implementation (H-0) is in the weak category, namely in the 1-5 cm / second range with the current heading west (Figure 4a). Meanwhile, when the sampling took place (D-24) the current velocity showed an increasing trend, namely in the range of 5-10 cm / second moving westward following the bay coastal area (Figure 4b). The wave height of a coastal area will accumulate marine litter in a location, with the waves potentially stirring up litter in the water column or settling on the substrate up to the surface, so that it is easily carried away by currents and accumulates on the beach. The main sources and movement pathways for plastics in the marine environment, with sinks occurring (1) on beaches, (2) in coastal waters and their sediments and (3) in the open ocean. Plastic litter can be blown away, carried by water, through the water column (including burial in sediments) and ingestion by marine organisms [14].

Apart from being influenced by geomorphological characteristics, weather conditions and oceanographic parameters, the distribution of marine litter on the Baiya beach is also significantly influenced by anthropogenic factors. Baiya Beach is located very close to residential areas both from the Mamboro Village and Palu City which has a relatively dense population and activities. In general, people who live in the Baiya coastal area work as fishermen and traders, so that the Baiya beach is also a mooring for boats (fishing boats), and also as a place for recreation (playing and swimming) for local people. These activities and conditions can directly increase the presence of litter (such as cigarette butts, plastics, metals, glass, fishing gear and others). Another very influential factor is the existence of several rivers that empties around the Baiya beach, such as the Taipa river, Pajeko river, Mamboro river and Palu river. The existence of these rivers causes the coastal waters of Baiya to receive a supply of fresh water which carries various particles and waste materials. During the rainy season, the river will carry piles of litter from local residents such as plastic bottles, food and drink packages, baby diapers and others, resulting in a build-up in marine waters and eventually distributed to the Baiya coastal area through currents, waves or wind. Apart from being surrounded by community settlements, Baiya beach is located in the Cape area which is directly adjacent to the Pantoloan port area which is densely packed with loading and unloading activities and containers, trading activities, especially culinary and goods suppliers operating around the port, as well as the existence of a waste disposal location in Panau village, which is close to the Baiya beach (south of Baiya beach). This condition makes Baiya beach very potential to be a location for accumulation of marine litter, moreover, Baiya beach is also the source of several rivers such as the Pantoloan river and the Tawaeti river as well as two tributaries namely the Mangu river and the Liku river. In general, the conditions and activities that exist in the area can have an impact on increasing the amount of garbage on the Baiya beach.

Plastic is the dominant marine litter because plastic is a pollutant that has been globally distributed throughout the waters due to its long-lasting and easy-to-float nature [13]. The litter proportion of plastic is dominant because its density is lower than the density of glass and metal so that it is easy to transport [14]. There are community activities that contribute to the entry of micro-plastic into the water through water channels. Marine litter comes from two main sources, namely: litter disposed of from household activities and from land through rivers [15]. The litter amount of plastic in the sea originates and is influenced by the activities and number of human populations.

Figure 5 and Table 2 shows that 13 of 24 plastic types, 1 of 5 foamed plastic-type, 1 of 5 rubber types and 2 of 5 the other materials in 2017. After the tsunami, 12 of 24 plastic types, 3 of 5 foamed plastic-type, 3 of 5 rubber types and 4 of 5 the other materials in 2019. The amount and type of plastic tends to increase in 2020 that 16 of 24 plastic types, 3 of 5 foamed plastic-type, 2 of 5 rubber types and 2 of 5 the other materials. It is mean that Monitoring marine litter at Baiya Beach in 2017 found 17 types of marine litter containing plastic. After the tsunami, the amount of plastic increased in 2019 (22 types) and 2020 (23 types). It is understandable that the tsunami event brought all materials, especially wood,
to land. The increase in plastic waste in 2020 shows the excessive use of plastic from the community. The dynamics of the coastal area also affects the litter distribution, which differs from time to time [13].

Coastal Clean-Up (CCU) is one of the countermeasures that can be carried out as a concrete action from the results of marine litter data generated in the previous year. CCU is also a means of educating young people in the country to maintain the coastal and marine environment. On September 7, 2019, the CCU on the Baiya Beach along 1 km with 482 participants (254 men and 228 women) was successfully implemented with a total of 3,216.3 kg of waste transported. Although the CCU has carried out after monitoring in 2019, the increasing trend of plastic use in 2020 shows that efforts have not been maximal in reducing the use of plastic in Palu City. Marine litter monitoring in Palu City has been ongoing since 2017. After the 2018 tsunami and recorded annually and analyzed the landings and trends in the amount of marine litter. Excess use of plastic needs to be reduced by optimizing cleaning and waste management efforts. Marine litter monitoring activities through the Environment and Forestry Ministry program provide important data before and after the tsunami, potential impacts, mitigation and environmental protection must be continued in the future.

4. Conclusion
The amount of marine litter before the tsunami on Baiya Beach in 2017 was found 4 meso litter materials with 10 litter types, 6 macro litter types with 24 litter types or a total of 17 litter types containing plastic. After the Palu Bay Tsunami in 2018, monitoring in 2019 found 9 materials of meso and macro litter materials with 31 litter types or a total of 22 litter types containing plastic. Monitoring in 2020 was found 9 meso litter materials with 19 litter types or a total of 23 litter types containing plastic. There are 9 types of macro litter, found 29 litter types. The increase in plastic litter on Baiya beach during monitoring was dominated by PL24 (other plastics) and the tsunami incident increased the litter types of plastic.

Acknowledgement
This research was funded by the Directorate of Pollution and Coastal Damage Control, Environment and Forestry Ministry. Thanks to the Team of The Palu City Environmental Office and Marine Research Centre & Coastal Community Empowerment-Tadulako University who assisted in marine litter monitoring.

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