Occurrence and distribution of microplastics in the beach sediment of Anday Beach, West Papua (Indonesia)

I C A Marei 1, F I E Saleh1, C Y Manullang2*, A Soamole2 and I Rehalat2

1Fisheries and Marine Science Faculty, Papua University, Jl. Gunung Salju, Amban – Manokwari, West Papua, Indonesia 98314, Telp/Fax: 0986 211675
2Research Center for Deep Sea – National Research and Innovation Agency (BRIN), Jl. Syaranamual Guru-Guru Poka - Ambon, Molucca, Indonesia

*E-mail: manullang.corry@gmail.com

Abstract. In the last two decades, scientists have extensively studied microplastics (MPs), small plastic pieces less than five millimeters long, which can be harmful to our ocean and aquatic life. The MPs in the environment came from the tiny particles designed for commercial use, such as cosmetics. The other sources come from the breakdown of larger plastic items. In this study, the occurrence and distribution of MPs were investigated in the Anday Beach of West Papua (Indonesia). The sampling was conducted from March to May 2019 on Anday Beach. The abundance of MPs found were 0.28 to 1 n/kg for MPs (1-5 mm) and 1140.6 to 1997.6 n/kg for MPs (< 1 mm). The highest abundance of MPs found on Anday Beach was plastic film. We suggest doing a regular beach clean-up to ensure the continuous assessment of marine litter in the coastal areas and extend the sampling area in Papua to record the plastic pollution status in the Papua.

Keyword: Anday Beach, beach sediment, microplastic, West Papua

1. Introduction
Plastic pollution has become a global problem threatening our environment. Every year, million metric tonnes of plastic have been estimated to end up in the oceans from coastal nations [1-3]. Other than that, Indonesia was ranked as the second-largest plastic polluter to the ocean [1]. This study has modeled that 10.1 million plastic waste in Indonesia is considered mismanaged with approximation 0.48 – 1.29 million tonnes are entered the marine environment per year. However, the Ministry of Industrial, Republic of Indonesia, had reported the estimation of plastic waste from Indonesia at a national scale in 2017. They have reported less amount of unorganized plastic waste from Indonesia. Around 4.8 million tons of plastic pollution has weighed to be mismanaged; 9% or about 620,000 tons of them are released into the water body (river, lake, and the ocean) [4]. In the latest report of the World Bank in 2021, the mismanaged plastic waste from Indonesia has been updated to 4.9 million tonnes [5].

There have been many well-founded reports of environmental damage due to plastic debris in the marine environment, such as nuisance trash in recreation beaches, inhibiting entanglement and ingestion of plastic in the marine wildlife [6-7]. The marine wildlife can be mistake plastic for prey or food [6]. Due to the chemical, biological and mechanic processes, plastic in the environment can break up into a smaller size plastic. The plastics with a size less than five millimeters in length are called microplastic [8]. These small particles are available to be ingested by various organisms. The marine
mammals such as whales, dolphins and seals [9], sea turtles [10], marine birds [11], crustaceans [12-13]; fish [14-18]; sea cucumber [19-20]; bivalves [21-23]; plankton [24-26] have been reported to be affected by microplastic debris.

Microplastic has been found all around the world, including in remote and isolated locations [27]. However, the lacking of proper waste management in developing countries has led them to contribute more plastic to the ocean. Solid waste management in the rural and remote areas of developing countries is more challenging compared to big cities because of such limited resources available, lacking infrastructure and facilities to treat the solid waste [28-29]. The top 20 countries that have been estimated to be the largest plastic contributors in the world were dominated by developing countries [1]. Furthermore, it is mentioned that mostly the mismanagement of plastic pollution in Indonesia comes from the rural areas or small-medium cities. Anday Beach in Manokwari, Papua Regency, is a fisherman village. No industries were built near this village. Nevertheless, no facilities are built to manage the solid waste in this coastal areas. This beach has been contaminated by plastic debris with an average concentration 31.20 item/m² for macroplastic (>25 mm) and 12.80 items per m² for mesoplastic (5-25 mm) [30]. For microplastic studies, limited data is available from the Papua region. To our knowledge, there is only one data set published from the Papua Region which reported the presence of microplastic in coral reef fishes of three small outer islands of Papua (Liki, Befondi, and Miossu). This paper reported for the first time of abundance of microplastic (MP) in the Anday Beach, Manokwari Regency in West Papua.

2. Methodology
Sampling was conducted from March to May 2019 in Anday Beach, Manokwari Regency in West Papua (Figure 1). The beach sediment of Anday Beach was taken three times, the time interval between sampling was two weeks. The methodology used in sampling was followed the [31]. The sand was collected from the high tide line up to the water edge line. Random samples were collected at the beach in four-zone over a hundred 100 meter stretch. The transects were divided into three zones: backshore (BS), strandline (SL), and water edge (WE). Each zone was divided into four sub-zones as a sample repetition (Figure 2). Quadrats (0.5 x 0.5 m) were placed in the zones to collect sediment to 2.5 cm depth using a stainless shovel. The next steps are drying, weighing, sieving, extraction, and sorting, were conducted in the laboratory.

Figure 1. Sampling location.
The samples were dried using an oven at 40ºC for 24 hours to remove water. After drying, the samples were weighed and sieved using a sieve shaker with a size of 1 mm. The material contained plastic on the sieving was sorted visually with the naked eye and recorded. The material under the sieving was re-weighted 400 g for MPs observation <1mm. The modified method from National Oceanic and Atmospheric Administration (NOAA) was followed to extract the MPs (<1mm) [32]. Samples were placed to saturate sodium chloride (NaCl) solution and stirred for ten minutes. Then, the samples were sieved and transferred into beaker glass then placed in the drying oven at 40 ºC. The solids are subjected to wet peroxide oxidation (WPO) with hydrogen peroxide (H₂O₂) 30%. The WPO solution was subjected to density separation in to isolate the plastic debris through flotation. The floating solids were separated from the denser undigested mineral components using a density separator. The floating plastic debris was collected in the density separator using filter paper. All microparticles that were collected on the filters were counted under a microscope. Due to the limited analysis instrumentation in our laboratory, in this study, the analysis of samples is only up to the counting of plastic under the microscope. The chemical determination of microplastic was not confirmed by polymer analysis.

The identification (shape and length) of MPs was carried out by a stereomicroscope. We counted all the MPs with lengths over more than 330µm. The MPs were physically categorized based on shape, namely: fragment/foam, film, fiber, and pellet. The MPs concentrations were reported in particles per kilogram (n/kg) dry weight (DW). One-way ANOVA was conducted to seek the correlation of concentration microplastic among the three zones of the beach (backshore, strandline, water edge).

3. Result and discussion

3.1. Large MPs (1-5mm)
The abundance of MPs (1-5 mm) in the Anday Beach from three times sampling were 1 n/kg for the first sampling, 0.87 n/kg for the second sampling, and 0.28 n/kg for the third sampling (Table 1). The highest number of MPs (1-5mm) was observed in the first sampling, and the lowest MPs were found in the third sampling. The most abundance of plastic was found in the BS, and WE zone (0.91 n/kg), the abundance of MPs in the strandline (SL) zone was 0.36 n/kg.
Table 1. The abundance of MPs (1-5mm) in the Anday Beach, West Papua.

| Plastic-type    | The abundance of MPs (1-5 mm) (item/kg) DW |
|-----------------|---------------------------------------------|
|                 | Sampling-1 | Sampling-2 | Sampling-3 | Average |
| Fragment/foam   | 0.18       | 0          | 0          | 0.06    |
| Film            | 0.64       | 0.82       | 0.23       | 0.56    |
| Fiber           | 0.18       | 0.05       | 0.05       | 0.09    |
| Total           | 1          | 0.87       | 0.28       | 0.71    |

Plastic film was the most abundant, with a percentage of 78% (Figure 3). The plastic film is relatively found high in the marine environment because this plastic type is widely used in the packaging, which mostly is single used plastic [33]. Furthermore, the polymer of this plastic is Polyethylene that has a lower density than seawater. Thus, it can be easier to be transported with seawater than other plastic [8]. Up to 91% of MPs (1-5mm) found in the Ambon Bay, Molucca was plastic-film [34-35]. In this study, no plastic pellet was recorded.

Figure 3. Percentage plastic-type found of MPs (1-5mm) in the Anday Beach.

3.2 Small MPs (<1 mm)
The number of MPs (<1mm) in Anday Beach was far higher than the MPs (1-5mm). A total of 7763 item MPs was found from the sandy beaches of Anday Beach. The highest MPs were recorded from the first sampling (2000 n/kg DW). Then 1700 n/kg DW and 1100 n/kg DW from the second and the third sampling, respectively (Table 2). The large difference number of MPs in both size categories might happen because the large MPs (1-5mm) can break to be smaller MPs (<1mm) due to the physical, chemical, and biological factors [8, 36]. The abundance of MPs (<1mm) between the three zones was relatively similar, which is 528 n/kg; 529 n/kg; 559 items/kg for zone BS, WE, and SL, respectively. Our one-way ANOVA analysis revealed that there was no significant correlation between the abundance of MPs (<1mm) among the three zones (BS, SL, WE). Fiber (65%), film (33%), and fragment (2%) were found where found in the beach sediment of Anday (Figure 4).
Table 2. The abundance of MPs (<1mm) in the Anday Beach, West Papua.

| Plastic-type | Abundance of MPs (<1 mm) (item/kg) DW |
|--------------|--------------------------------------|
|              | Sampling-1  | Sampling-2  | Sampling-3  | Average  |
| Fragment     | 51.9        | 26.3        | 15          | 31.1     |
| Film         | 1331.3      | 1135        | 690         | 1052.1   |
| Fiber        | 614.4       | 552.5       | 435.6       | 534.2    |
| Total        | 1997.6      | 1713.8      | 1140.6      | 1617.4   |

Figure 4. Percentage plastic-type found of MPs (<1 mm) in the Anday Beach.

4. Conclusion and recommendation

This study has confirmed the presence of MPs in Anday Beach, West Papua. The most abundant plastic type was plastic film. Due to the presence of plastic waste in Anday Beach, more innovative ways for litter management and effective implementation of pollution laws are essential to control the menace of debris entering the coastal areas. We suggest conducting an extended sampling area in Papua to describe the plastic pollution status in Papua and some action that needs to be documented the marine litter in the remote islands such as Anday Beach.

a) Routine regional monitoring programs

After Indonesia ranked as the second larger pollutant into the ocean [1], many of the institutions have programs to address marine litter by doing regular beach clean-up and in the mangrove area as well. However, these activities are seasonal and often only collect the garbage without documenting any of the data garbage (i.e., type, numbers, or weight of litter). Therefore, there is still a need to establish regional monitoring programs to ensure the continuous assessment of coastal areas. The monitoring programs can be conducted weekly or monthly to monitor the litter on the beaches or mangrove forests in the same coordinate and the same tide period. The collection of regular data would be a great way to study the main sources of marine litter in a coastal area and determine if there are any peak periods of marine debris that goes to the coastal area. Providing long-term monitoring data in several areas would help out the government to concept the way to mitigate the marine debris in the coastal area and the mangrove forest as well.

b) The monitoring recycling program.
As a rural area, Anday Beach has a limited carrying capacity and a lack of facilities in the waste management system. However, the using plastic in all aspects of human life continues to increase. Almost all aspects of daily life involve plastics. Therefore, recycling programs can be used to minimize the amount of litter in the waste stream. The government needs to push the companies which use plastic in their packaging to encourage the community to separate their garbage and send it back to the companies to be recycled. In some developed countries, this new way of recycling mode indicates an act of increasing courage to do recycling in the community.

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