

# Microplastics in Sumba waters, East Nusa Tenggara

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**Abstract.** The accumulation of plastic debris in the oceans has been widely recognized as a threat to marine environment. A recent study estimated that Indonesia is one of the biggest sources of plastic wastes in the ocean, but directly-measured abundance data from the seawater in Indonesia is lacking. We documented the abundance and distribution of microplastics (size <5mm) in sub-surface seawaters of Sumba, a pristine region in Indonesia. Water samples were collected from 5 m, 50 m, 100 m, 300 m depth and near the sea bottom. Samples were examined for microplastics using flotation and filtration methods. We found microplastic in all sampling locations, consisting of fibers (45.45%), granules (36.36%) and other plastic form (18.18%). Most of microplastic particles were found at water depths less than 100 m (81.82%), which was the thermocline area. Our finding corroborates the believe that plastics has widely invaded marine environment in different parts of the seas and oceans, including pristine, remote, and unknown areas.

## 1. Introduction

Plastics are a successful story with regard to their characteristics that make them suitable for a wide variety of products [1]. By 2014 the total plastic production reached 311 million tons [2]. High consumption rate but low recovery rates has driven plastics to be a potential threat to the environment. [3] reported that most of plastic packaging is not recovered, of which 40% goes landfilled and 32% leaks to the environment including marine ecosystem. Plastic pieces that ended up in the environment remain still with very slow degradation (up to 100 years). Recent studies estimated that plastic debris in the ocean are between 7,000 – 250,000 metric tons [4,5]; land based input to the oceans are between 4.8 - 12.7 metric tons; and Indonesia was listed as one of the top sources of land based input [6]. This estimation, however, lacks real abundance data in the ocean since it used mathematical model based on solid waste production, population density and economic status of the countries.

Plastic pollution was initially seen as an aesthetic problem [7,8], however recent studies have shown that marine animals can be negatively affected by the presence of plastics. Threats posed by plastics with large size are obvious, clear environmental risks by physical impairment after swallowing, entanglement [9]. [10] stated that from the 1960s to 1990s, physical impairment caused by plastics had increased almost three times (267 to 693 species). Furthermore, [9] reported that all seabird species (395 species) contained plastics in their digestive systems.

Plastic waste can be degraded by UV thermal oxidation or mechanic processes up to the microscopic size [11,12]. Microplastics (<5mm) are formed by the physical, chemical and biological fragmentation of larger items of plastics. Besides commonly-used plastics, microplastic may originate from cosmetic or fabric, in the form of microbeads [13,14]. The impact of microplastics in the marine environment are



not clearly known. Studies in the last decade have indicated potential environmental risks from microplastics, but real consequences are mostly unknown. Microplastics accumulation in gastrointestinal on marine organism has been reported [15–19], but the impact of the accumulation to the organisms are not known. Microplastics could enter the food web by organism ingestion [20], could interference digestive tract function [17], and may act as a carrier for organic material and heavy metals [21–23].

Sumba, located in East Nusa Tenggara, Indonesia, is a pristine region in the outlet of Indonesian Through Flow (ITF) connecting the Pacific Ocean and the Indian Ocean. It is in the southern part of the Wallacea transition zone, where Indo-Malaya and Australasian biogeographic characteristics meet. It has unique marine ecosystems and high biodiversity. This area is an important migration corridor to many marine megafaunas and pelagic fishes. Here, we documented the abundance and distribution of microplastics (size <5mm) in sub-surface seawaters of Sumba.

## 2. Introduction

### 2.1. Study area

Sumba is located in East Nusa Tenggara, eastern Indonesia (Figure 1). Sumba waters area is believed to have high marine life, but minimal scientific information. From the perspective of oceanography, this area is also believed to be unique because of the interaction between Indonesian Through Flow (ITF/Arlindo). The presence of four water masses on the western side, north and south of Sumba Island (Northern Pacific Subtropical Water-NPSW, North Pacific Intermediate Water-NPIW, Northern Indian Subtropical Water-NISW and Northern Indian Intermediate Water-NIIW), proves that this area is an outlet of ITF [24–26]. A front near the western tip of Sumba Island potentially trigger an eddy and might be influenced by the South Java Current (SJC) [24–26]. This current is believed to trigger upwelling which is important for fishery resources. In addition, oceanographic process also believed to be important in Sumba region is mixing, that is the mixing of water masses that can occur due to tidal currents, bathymetry, and internal waves.

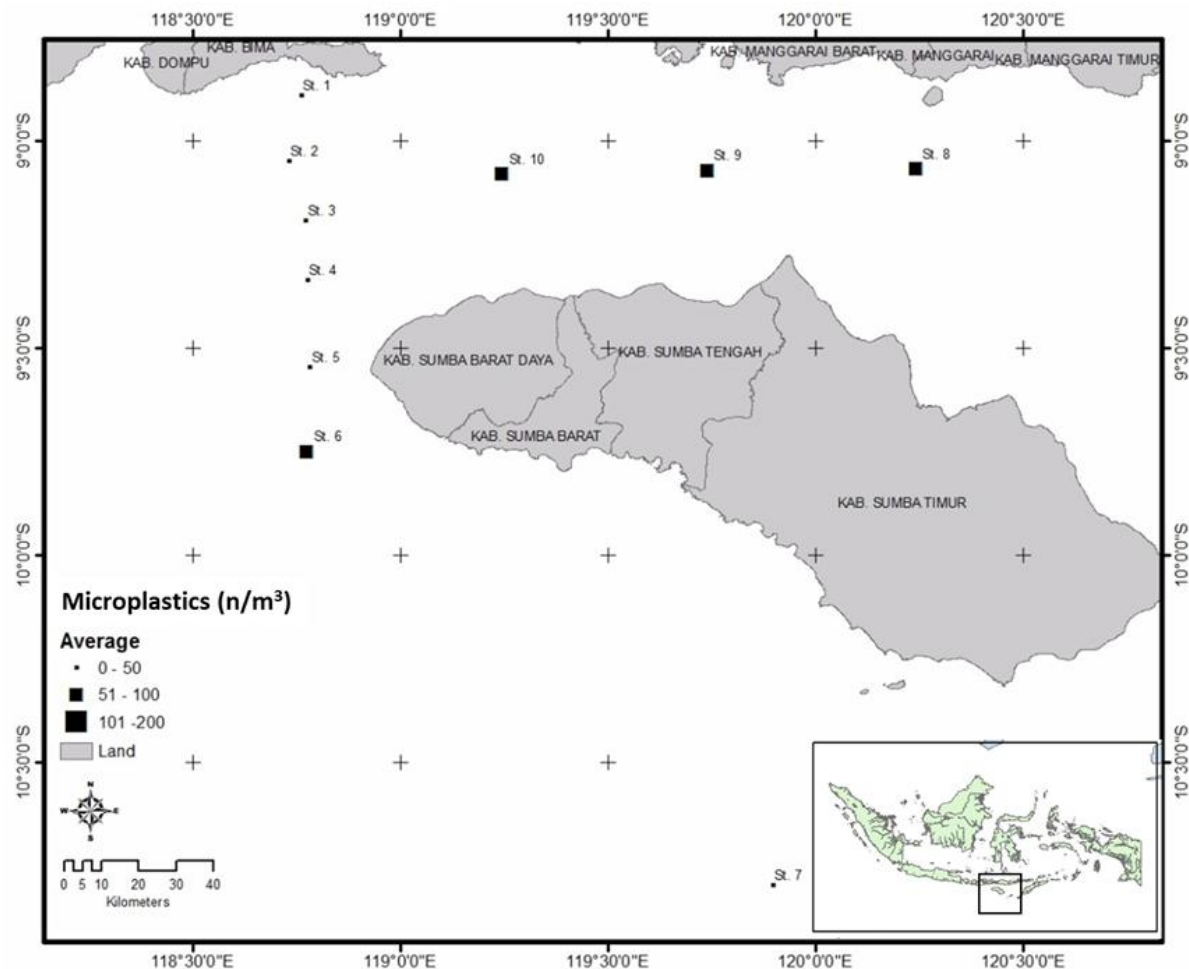
### 2.2. Sample collection

Sampling was conducted during the 9th Ekspedisi Widya Nusantara (EWIN IX) in August 2016 using RV Baruna Jaya VIII. Sampling sites are shown in Figure 1. Water samples (10 liters per depth per site) were collected using Rosette Water Sampler at 5 m, 50 m, 100 m, 300 m and near the sea bottom, then were filtered using a sterile Whatman® cellulose nitrate filter papers (diameter 47 mm; pore size 0.45µm). To accelerate filtration process, we used Gast vacuum DOA-P504-BN. All samples in the filter papers were stored at 4±2 °C before analysis in sterile Petri dish and covered with ParaFilm® sealing film. To prevent samples from being contaminated, we wore laboratory latex gloves and eyeglasses for filtering, sorting and counting. All sterile glassware were used and filters were stored in Petri dishes, sealed with Para Film.

### 2.3. Sample analysis

Microscope Leica M205C was used to examine microplastics particles on the filters. We were using the following characteristics [17,27,28] to identify microplastics, namely (1) particle size ≤ 5mm, (2) homogeneous colour, not shiny or sparkling and no cellular or organic structure, (3) fiber particles are unbranched and not segmented. The microplastics identified were counted and measured. The types of microplastic then were classified as fibers, granule, fragment, and foam; and were categorized to the size of <300µm; 300-500µm; 500-1000µm; >1000µm. We analyzed microplastics with sizes more than 250µm using Fourier Transform Infrared (FT-IR). FT-IR can be used to analyze microplastics samples directly [29]. Polymer analysis was done using Nicolet™ iS5 FT-IR Spectrometer, equipped with a laminated diamond crystal Thermo Scientific™ iD5 attenuated total reflectance (ATR) accessory, and corrected using Omnic™ Software. The instrument was operated based on [30] at a range of 600 and 3800 cm<sup>-1</sup>, a resolution 8 cm and at a rate of 16 scans per analysis, in single reflection mode. Before we analyzed using FT-IR, all potentially plastic particles were rinsed with ethanol 96%. To prevent

samples from airborne contamination, we analyzed all particles based on a report by [31]. Afterwards, we did not quantify the fiber particle of the same polymer type as the lab clothes we have worn. Microplastics concentration are presented as  $\text{n/m}^3$  unit (Table 1) to compare with other research result, simple statistical tests were performed on the data collected using Microsoft Excel are presented mean values  $\pm$  standard deviations (SDs).

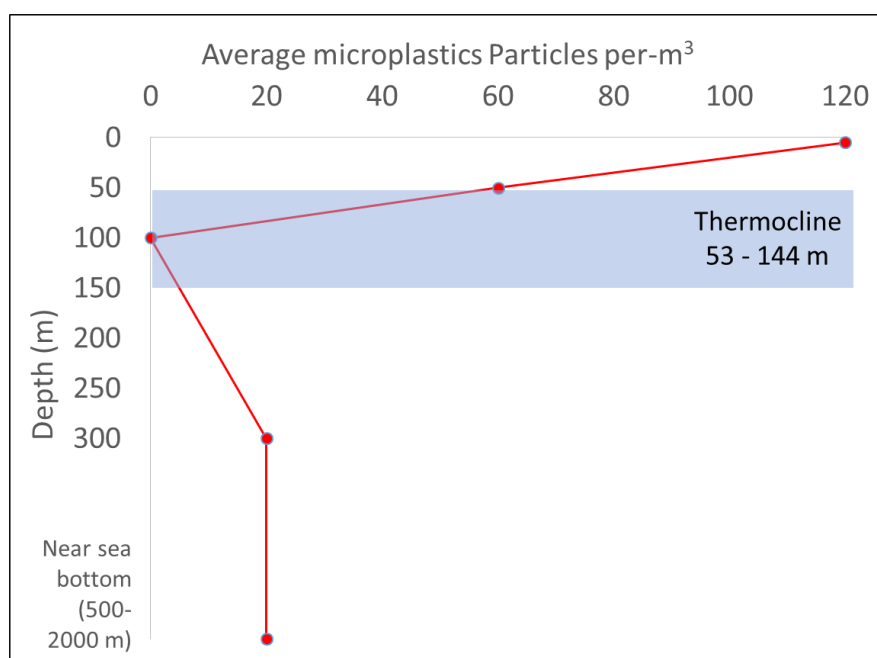


**Figure 1.** Sampling sites and average abundance of microplastics particles in five different depth (5 m, 50 m, 100 m, 300 m depth and near the sea bottom)

### 3. Results and discussion

#### 3.1. Study area

Plastic particles were found in all sampling location (10 sampling locations). Average microplastics concentration per station in five different depth were  $44 \pm 24.59 \text{ n/m}^3$ . The highest concentration of microplastics was observed in Sumba Strait (St-8 and St-10). At 5m depth, microplastics particles were found in all sampling locations (Figure 2). However, microplastics was not observed at 100m depth. This might be related to the presence of thermocline zone, ranging from 53m to 144m depth.



**Figure 2.** Average of microplastics abundance (n particles/m<sup>3</sup>) in all station at five different depth in Sumba Sea

Microplastics abundance at 5m depth was nearly similar with that of the coastal area in Yangtze estuary China [32,33]. The abundance in this area was higher than that of other open oceans, for example North East Atlantic Ocean (2.46 n/m<sup>3</sup>; [34]), East China Sea (0-1.44 n/m<sup>3</sup>; [33]), and North West Mediterranean (0.116 n/m<sup>3</sup>; [35]). The wide variety of microplastic abundance in different oceans might be related with the fact that microplastics tend to be heterogeneously distributed in a water mass [36]. Because Sumba region is one of the ITF outlets [24–26], characterized by four water masses (NPSW, NPIW, NISW, NIIW), we believe that microplastics observed in Sumba might not only come from anthropogenic activities around [28] Sumba, but also from other parts of the oceans in the Pacific.

**Table 1.** Microplastics occurrence, characteristic and polymer composition

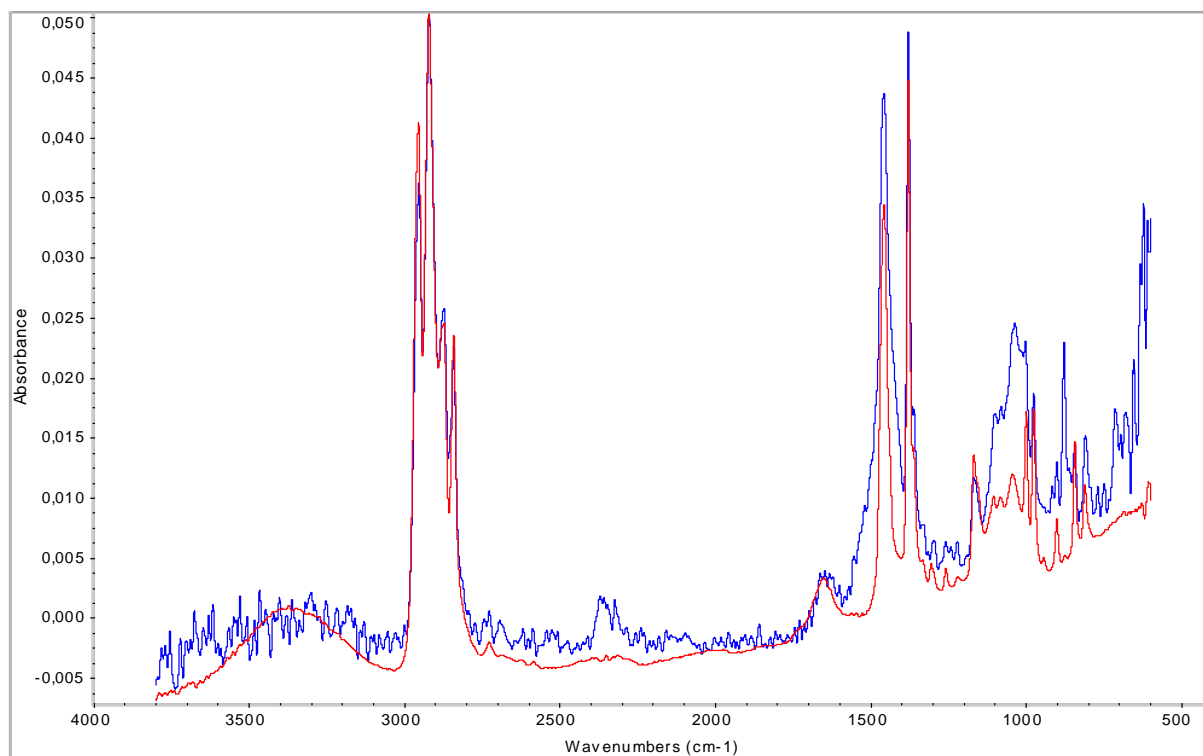
Size	Form			Percentage (%)	Polymer				Percentage (%)
	Fibers	Granule	Other		PE	PS	PA	PP	
<300µm	1	1	0	9.09	1	0	0	0	4.55
300-500µm	3	2	4	40.91	4	2	1	1	36.36
500-1000µm	4	5	0	40.91	5	0	0	4	40.91
>1000µm	2	0	0	9.09	4	0	0	0	18.18
Percentage (%)	45.45	36.36	18.18		63.64	9.09	4.55	22.73	

PE- Polyethylene; PS- Polystyrene; PA- Polyamide; PP- Polypropylene

### 3.2. Microplastics occurrence, characteristic and polymer composition

We classified microplastics from Sumba into four size categories: <300µm, 300-500µm, 500-1000µm, and >1000µm; and into three forms: fibers, granule, and other type (fragment, foam) (Table 1). In all sampling stations, microplastic size ranges from 280µm to 1120µm. Most of identified microplastics (81.82%) were 300-1000µm in size. Fibers were the most abundant form (45.45%), followed by granule (36.36%) and other type (18.18%). We identified four dominated categories of plastic polymers:

Polyethylene (PE), Polystyrene (PS), Polyamide (PA) and Polypropylene (PP). PE was the most common dominated polymer type, followed by PP, PS, and PA (Table 2).



**Figure 3.** Example of comparison of the spectrum of polypropylene polymer standard from Thermo-scientific (red) and a spectrum obtained from the measurement of a dominated polypropylene fragment particle found in Sumba waters (blue) by ATR-based FTIR spectroscopy

Figure 3 shows examples of the polymers found, which dominated with Polypropylene (PP). From fragment particle sample, prominent presence peak at wavenumber  $2950\text{ cm}^{-1}$ ,  $2916\text{ cm}^{-1}$ ,  $2837\text{ cm}^{-1}$  and  $2868\text{ cm}^{-1}$ . Similar observation by [37] for PP samples indicated peak at  $2951\text{ cm}^{-1}$ ,  $2911\text{ cm}^{-1}$  and  $2844\text{ cm}^{-1}$  indicating an asymmetrical type of vibration ( $\nu_a\text{-CH}_2$ ) [38]. Those were similar displayed vibration bands of polymer standard at  $2950\text{ cm}^{-1}$ ,  $2917\text{ cm}^{-1}$ ,  $2869\text{ cm}^{-1}$  and  $2837\text{ cm}^{-1}$ . In this study, fragment particle found in Sumba waters and polypropylene polymer standard (Figure 3) showed an absorption band at  $1375\text{ cm}^{-1}$  and at  $1454\text{ cm}^{-1}$ . Spectrum of PP showed symmetrical deformation vibrations ( $\delta_s\text{-CH}_3$ ) at  $1372\text{ cm}^{-1}$  and asymmetrical deformation vibrations ( $\delta_a\text{-CH}_3$ ) at  $1458\text{ cm}^{-1}$  [37,38].

Size of microplastics could determine the potential impact to the organisms [28]. Smaller size increase the possibility of microplastics ingested by the organisms [33,39]. This situation may pose potential negative impacts to various marine megafauna and important pelagic fishes. Microplastics with size  $<1000\text{ }\mu\text{m}$  frequently founded on marine organism digestive tract [16,18,19,40], suggesting that marine organisms likely mistake microplastics as their food [41]. Microplastics could disrupt digestive tract function [17] and could also act as a vector for organic and heavy metal pollutants [21–23,42,43]. The most common form was fiber microplastics, similar to the findings by [28,33,44,45]. Fibrous plastic particles in Sumba might derive from fishing nets and rope materials; granule comes from hard plastics and granulated cleaner [45]. Based on FTIR analysis, most polymers identified were dominated polyethylene, followed by dominated polypropylene and dominated polystyrene. The primary use of polyethylene is packaging materials, e.g. food and beverage containers, geomembrane plastic bags and film. Polypropylene is widely used in food and beverage containers, clothing industry, ropes, and reusable containers [46–48]. Surprisingly, polyamide fiber was also found in Sumba. This fiber might

derived from fishing nets and rope material [49,50]. Despite the fact that plastics are newly developed materials (early nineteen centuries made), our finding, that microplastics was found in seawater of Sumba at all surveyed depth, indicated that plastic has invaded marine areas, including pristine areas. It confirms the common believe that plastic waste has spread widely to different parts of the seas and oceans, including remote and unknown areas [51].

#### 4. Conclusion

Our study reports that microplastics were found in all sampling locations, in the form of fibers (45.45%), granules (36.36%) and other form (18.18%). Most of the microplastic particles (81.82%) were found at water depths less than 100m, which were thermocline area. However, no microplastics was observed at 100m depth. Most of identified microplastics (81.82%) were in 300-1000 $\mu$ m in size. Dominated plastics polymers identified were polyethylene, followed by polypropylene, polystyrene, and polyamide. Further studies are planned to examine microplastic distribution in the region where ITF presence and to investigate the potential impact of microplastics in that area.

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