Microplastic abundance in anchovy *Stolephorus indicus* (Van Hasselt, 1823) in the Lada Bay, Pandeglang, Banten

E Hardianti, W Wardhana and M P Patria

Department of Biology, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia

Corresponding author’s email: mpatria@sci.ui.ac.id

Abstract. Currently, microplastic is one of the serious threats to the marine environment. This research aims to investigate the abundance and types of microplastics contained in anchovies *Stolephorus indicus* and water from Teluk Lada (Lada Bay), Tanjung Lesung, Pandeglang, Banten. Anchovy samples were extracted with 1M NaOH and 5 % sodium dodecyl sulphate (SDS). Meanwhile, water samples were treated by mixing it into NaCl concentrate solution. The results show that 246.10 ± 32.25 ind⁻¹ and 156 ± 13.46 L⁻¹ microplastic particles were found in the anchovies and water, respectively. In addition, 216.30 ± 30.13 ind⁻¹ microplastics were found in the anchovies taken from traditional market as a control. The types of microplastics found in anchovies were fibers (77.41 %), films (16.64 %), fragments (5.6 %) and a little amount of granules (0.35 %). Meanwhile, the water samples were contained with fibers (81.03 %), films (11.92 %), fragments (7.0 %) and a little amount of granules (0.05 %). Our study found that fibers were the dominant pollutant in all samples and the amount of microplastics contained in water is strongly related to the amount of microplastics found in anchovies.

Keywords: *Stolephorus indicus*, microplastic, Lada Bay, abundance

1. Introduction

The total global plastic production reaches 245 million tons per year. Plastics are needed in many areas of modern life, which are used for clothing, storage, transportation, packaging and construction. The increasing plastic production also increases the use of plastic, which causes an increase in the accumulation of plastic materials in the environment. Plastic waste contributes around 75–80 million tons of plastic every year which end up in and contaminate the ocean [1]. Plastic waste in the marine environment comes from beaches, fisheries, the marine industry, and waste from cities brought by rivers to the sea [2, 3]. Indonesia is one of the second largest contributors of plastic waste in the sea after China [4].

Plastic waste that must be removed is slowly degraded into small pieces due to the changing size of the environment. Fragmented plastics with sizes smaller than 5 mm are known as microplastics [5]. Plastics that originally produced in very small sizes are called primary microplastics while plastics that are large in size can mechanically be degraded into smaller sizes due to exposure to UV radiation, wind, waves, or animals producing the secondary microplastics [6, 7]. Microplastic can release plasticizer and pollutant adsorbed after consumption by various marine organisms [8].

Microplastics contain chemicals that can absorb POPs (Persistent Organic Pollutants) and PBTs (Persistent, bioaccumulative and toxic substances) compounds from the surrounding sea water [9].
Concerns about the potential impact of these chemicals if particles are ingested by individual organisms or larger populations can cause ecotoxicological problem that is able to disrupt the marine food webs, especially at the level of primary producers [10]. Organisms that are exposed to microplastics, accumulate it in the body tissues according to the digestive tract [11]. Effects on organisms can cause toxicity such as inflammation that can interfere the bodily functions [10].

Microplastic has been observed in a number of animals that have commercial importance, one of which is fish. Anchovy is an abundant fish and a source for seabirds and predatory fish. Anchovy is zooplanktivorous as an adult so it is important in marine food webs [12]. Microplastics can be ingested through passive water filtration and deposit feeding [13]. Microplastics can be transferred from the environment to organisms, and then through the food web, that is, transferred from prey to predators.

Anchovy has a consumption size of ± 5–14 cm so that all parts of the body can be consumed intact. Concerns about human consumption of microplastics through the consumption of fish contaminated with microplastic particles have potential hazards such as physical, chemical hazards (unbound monomers, additives, and chemicals absorbed from the environment), as well as microorganisms that attach to and colonize in the microplastics, known as biofilms [14].

Tanjung Lesung is an area in the Lada Bay waters which has a Special Economic Zone (SEZ) region, is a rapidly growing tourism development because there is industrial complex such as the trade, hotel and restaurant sector, as well as the processing industry [15]. Industrial activity increases the amount of plastic used such as plastic waste that accumulates in the ocean increases. Lada Bay waters is also a center of fishery activities, one of which is anchovy [16]. Anchovy is an important commodity for the people of Indonesia, because it has been marketed in almost all parts of Indonesia and has become one of the export commodities [17]. The high level of industrial activity causes pollution in the waters of Lada Bay, giving rise to the possibility of microplastic contamination in the water.

2. Materials and method

2.1. Study area
Data were collected in Lada Bay, Pandeglang, Banten (S 6° 28’ 45” – 6° 28’ 57”; E 105° 42’ 16–105° 43’ 48”). The Lada Bay receives fresh water from the Bama River, Cibungur River and Ciliman River (figure 1). Microplastic analysis of each sample was carried out in the marine biology and physiology laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Indonesia, Depok.

2.2. Sampling and water quality measurement
The field parameter data was collected in the Lada Bay, Tanjung Lesung, Pandeglang Regency, Banten (figure 1). Environmental parameters were taken from each of 3 stations with repetition as much as 3 times and taken an average. Environmental parameters measured and recorded were covered the temperature, salinity, pH and dissolved oxygen (DO). Sampling of 20 L of surface water was carried out using a dipper then filtered with 300 μm mesh diameter of the plankton net. The results of the filtered water were then stored in a glass bottle. The anchovy sampling was done at night using the waring framework found in the fish bagan. Preservation of fish samples was done by pouring 70 % alcohol into a sample bottle. Sampling was carried out on 3 different fish bagan, with distances between fish bagan was ± 1–3 km. Anchovy samples as a comparison were taken from the Panimbang traditional market, Panimbang Jaya village, Pandeglang, Banten as many as 10 individuals.

2.3. Microplastic extraction

2.3.1. Extraction on fish muscle of anchovy. NaOH (technical grade) and SDS (sodium dodecyl sulphate) were prepared and put into a glass beaker filled with distilled water to make 1 M NaOH and
5% SDS. The average total number of microplastic particles calculated at 1 mL was observed and multiplied by 15 mL of the homogenized sample (figure 2).

2.3.2. Extraction on water. The surface water samples from the three locations were filtered using sieve net 5 mm in mesh, then mixed with saturated NaCl that was prepared to increase the density sample so that microplastic particles float on the surface. The ratio mixture was 1:3 volume of water (mL) with the volume of NaCl solution. The mixture was stirred for 2 min then allowed to stand for 24 h to separate the plastic from the impurity. The sample that has been left was taken as much as 20 mL from the surface of the water with a pipette. Samples were stored in an Erlenmeyer flask and homogenized, then taken as much as 1 mL and then dropped into a counting chamber to be observed under a microscope.

2.3.3. Data analysis. Statistical analysis of the results of these studies were in the form of qualitative and quantitative data. The qualitative microplastic statistical analysis of water and anchovy samples was used to display the data in tables, diagrams and graphs in the form of common microplastic forms such as fibers, fragments, films and granules that aim to determine the microplastics that accumulate in the water and anchovy samples. The Spearman correlation test was aimed to determine the number of microplastic particles in water in the waters of Lada Bay, Tanjung Lesung as an independent variable of the number of microplastics in anchovy as the dependent variable. The test showed a positive correlation and a negative correlation with the degrees of confidence α 0.05.

Figure 1. Map of research locations in Lada Bay
3. Results and discussion

3.1. Microplastic abundance in water and anchovy

Anchovies *Stolephorus indicus*, obtained from three stations have the average ± 1.1 gram mass, with ± 5 cm in length. The calculation of the amount of microplastic particles in anchovies is based on the average amount of microplastic particles found in 3 individual anchovies at each station. Types of microplastic from size ± 14.84 μm until 1 mm were found in anchovy samples. Fiber, film and fragment microplastics were found in all anchovy samples at each station, but granules were only found in sample 1 of 3 anchovies from station 1, station 2 and the traditional market. The abundance of average microplastics in anchovies from station 2 has higher microplastics than station 1, station 3 and the traditional market. In total, the microplastics were found at station 1 (228.33 ± 48.04 particles ind⁻¹), station 2 (278.33 ± 30.5 particles ind⁻¹), station 3 (226.67 ± 10.40 particles ind⁻¹) and in the traditional market (216.67 ± 30.13 particles ind⁻¹) (figure 3).

From 3 water samples per station, we found fiber, film, and fragment microplastics type at all station, but granules type was found only at station 1 and 3. The highest microplastic abundances in the water sample was recorded at station 2 with 170.56 particles L⁻¹, then station 1 with 153.33 particles L⁻¹, and the lowest microplastic abundance was at station 3 with 144 particles L⁻¹ (figure 3).

Lada Bay are populated areas, one of them is Panimbang Village. Lada Bay gets the water supply from Bama River, Cibungur River and Ciliman River, so that plastic waste and domestic waste that are degraded into microplastics get into Lada Bay waters. Water waves triggered by the meteorological condition, such as wind, are expected to cause microplastic turbulence in the water surface that causes a bigger fluctuation. Microplastic distribution is assisted by wind, water currents, upwelling, downwelling, and waves. The release of domestic industrial waste causes poor water quality, and the

---

**Figure 2.** Extraction scheme in anchovy
posibility of positive correlation between poor water quality and high microplastic concentration could indirectly reinforce the idea that microplastic abundance is affected by economic activities [18].

Microplastic concentration at station 2 was higher than other stations. The station 2 has a closer fish bagan density range, so it reveals that high microplastic concentration could be affected by the intense human activities in that area. High abundance could occur due to several factors. The first factor is the high level of pollution from water source, and domestic waste from the land carried by river.

The wide microplastic distribution in aquatic ecosystems makes various aquatic organisms potentially vulnerable to the emerging contaminants. There are some ways of organisms that could accumulate the microplastics into the body. Organisms that are exposed with microplastic could be contaminated through gill [19] and gastrointestinal tract [20]. Microplastic ingestion happens due to the inability of organism to distinguish the microplastic and prey and contaminated through the low tropic level organism, such as plankton that contain microplastic [21]. Its small size makes it easy for organism to eat these particles. This theory supports that anchovies are accidentally contaminated in consuming plastic, when they look for food by swimming and open their mouth, water passes through the mouth and is removed by the gill, as the particles are filtered by the gill and moved through esophagus. Water containing microplastic might contaminate anchovies [22]. Microplastic particles contain colors, so that they are similar to prey to be eaten by animals. Research shows that the color may be an important factor in mediating the interactions in looking for food [23].

Commercial fish that are exposed to microplastics causes the potential of exposed microplastics into the human body through seafood consumption which contaminated by microplastic particles. Microplastics have been widespread which cause biological impacts on organisms in marine environment [24]. The bad effect of microplastics on marine organisms could potentially give physical effects like gastrointestinal tract failure. Microplastics could act as vectors for chemical transportation to marine organisms that cause chemical toxicity (additives, monomers, and absorbed chemicals).

The main composition of the types of microplastic in water, anchovies from Lada Bay, and the market is fiber particle, each station has the sequence of composition of the same types of microplastics that is fiber > film > fragment > granule. Fiber particles in the water have a higher percentage than anchovy samples from Lada Bay that are 81.03 % with the amount of fiber particles of 126 ± 10.50 particles L⁻¹. Meanwhile, the percentage of fiber in anchovies is 77.41% with the amount of microplastics of 186.65 ± 25.19 particles ind⁻¹. Film particles are dominated by anchovy samples from Lada Bay.
with the percentage of 16.64% with the amount of 42.20 ± 6.74 particles ind⁻¹. The percentage of fragment particles between water and anchovy samples are 7.0 % and 5.60 %. Granules in anchovies and water have the percentage of 0.35 % and 0.05 % because these only found in 1 of 3 anchovies at station 1 and station 2, while in water found at station 1 and station 3. Anchovies from the market has a higher percentage of fiber than anchovies in Lada Bay that is 81 % (figure 4).

Fiber has a higher amount due to its sampling location near the fishing activities that becomes the fiber microplastic sources such as textiles of domestic waste and synthetic cords (fishing lines and nets in the fish bagan) [24]. Film, fragment, and granule are more difficult to detect because they are more similar to the undigested plant material or sediment grains so they could be underrepresented in its amount [25].

Film microplastic is in the second sequence followed by fragment, allegedly came from the damaged disposable plastic bags in accordance to the flat and thin appearance. Film is relatively transparent than fragment. Fragment has a thicker shape consisting of PP that could be part of food packaging or plastic labels. Polycarbonate and Polystyrene have higher densities (1.20 and 1.05 g/cm³, respectively) than water. Microplastics on the water surface might be caused by microplastic resuspension from sediment triggered by natural conditions such as tides and waves [26]. Granule particles are less on the water surface, no waste found from the care products or cosmetics containing microbeads in Lada Bay waters, so that granules are hardly found in this research (figure 5).

**Figure 4.** Percentage of microplastics has been found in Lada Bay.
Figure 5. Types of microplastics were found in water and anchovy (*Stolephorus indicus*) samples; (a) fiber, (b) and (c) film, (d) and (e) fragment, and (f) granules.

Table 1. Correlation of microplastic on water to anchovy individuals.

| Types of particle | Correlation | Value of count |
|-------------------|-------------|----------------|
| Fiber             | Water- *S.indicus* | 0.775          |
| Film              | Water- *S.indicus* | 0.858          |
| Fragment          | Water- *S.indicus* | 0.833          |
| Granule           | Water- *S.indicus* | 0.983          |

3.2. Correlation between microplastic on water and anchovy

The amount of microplastic particles like fiber, film, fragment, and granule in water and anchovy shows the result $r_s > r_p$ so that Ho is rejected. The conclusion shows that positive correlation with confidence degree of 0.05 ($p_{table}$: 0.683). The amount of microplastic contained in water samples is not much differed from the microplastic in anchovy as there is accumulated microplastic in pelagic zone, so the interaction occurred between marine organism and water containing microplastic (table 1).

3.3. Water quality at Lada Bay

The environmental parameters are highly important to determine how organisms are affected by the abiotic factors as measurement of survival rate, growth, and stressor of their environment. The measurement result obtained from the measurement of environmental parameters data conducted in Lada Bay Waters, Pandeglang, Banten reveals that the temperature of Lada Bay is about 28–29 °C, pH between both of them has no difference (7), salinity is at 35–36 ppt, and oxygen is about 7.7–7.9 mg/L.
The results of these measurements show that environmental parameters at each station are within the optimal limits for anchovies so it could still support the anchovy’s growth and development. The measurement of environmental parameters helps to identify the potential sources of fragmented microplastics. Understanding between microplastic concentration and water quality characteristics enable a more accurate estimation of microplastic emissions.

4. Conclusion
This research shows that microplastic particles do not only pile up in waters, but also could be digested by the aquatic organisms like anchovies. Fishing activities and domestic waste are the main contributors of microplastic abundance in Lada Bay. Besides human activities, the distribution pattern of microplastic contamination could also be affected by hydrodynamic and topographic conditions. Our results provide a basic information about microplastic pollution status in Lada Bay. The government should improve the waste management facilities and optimize the wastewater treatment plant process. We also suggest that the impact of microplastics in aquatic ecosystems needs to be learned and could conduct further research to know how many anchovies that could be consumed by people and the potential of further danger of microplastics for humans.

Acknowledgments
This work was financially supported by Universitas Indonesia under research grant PITTA B with grant contract number NKB-0642/UN2.R3.1/HKP.05.00/2019 to M. P. Patria.

References
[1] Andrady A L 2011 Mar. Pollut. Bull. 62 1596-605
[2] Cole M, Lindeque P, Halsband C and Galloway T S 2011 Mar. Pollut. Bull. 62 2588-97
[3] Veiga J M et al. 2016 MSFD GES TG Marine Litter Thematic Report-JRC Technical Report EUR 28309 (Luxembourg: European Union)
[4] Jambeck J R et al. 2015 Science 347 768-71
[5] Chatterjee S and Sharma S 2019 Field Actions Sci. Rep. 19 54-61
[6] Group of Expert on the Scientific Aspects of Marine Environmental protection (GESAMP) 2015 Sources, Fate and Effects of Microplastics in the Marine Environment: A Global Assessment (London: Micropress Printers Ltd.)
[7] Boucher J and Driot D 2017 Primary Microplastics in the Oceans: A Global Evaluation of Sources (Switzerland: IUCN)
[8] Smith M, Love D C, Rochman C M and Neff R A 2018 Curr. Environ. Health Rep. 5 375-86
[9] United Nations Environment Programme (UNEP) 2016 Marine Plastic Debris and Microplastics (Nairobi: UNEP)
[10] Avio C G, Forbis S and Regoli F 2017 Mar. Environ. Res. 128 2-11
[11] Anbumani S and Kakkar P 2018 Environ. Sci. Pollut. Res. Int. 25 14373-96
[12] Savoca M S, Tyson C W, McGill M and Slager C J 2017 Proc. Biol. Sci. 284 1-8
[13] Barboza L G A, Vethaakde A D, Lavorante B R B O, Lundeybe A N and Guilhermino L 2018 Mar. Pollut. Bull. 133 336-48
[14] World Health Organization (WHO) 2019 Microplastics in Drinking-Water available at https://www.who.int/water_sanitation_health/publications/microplastics-in-drinking-water/en/
[15] Meliana K D and Buchori I 2016 Jurnal Pembangunan Wilayah dan Kota 11 49-60
[16] Susanto A 2105 Jurnal Ilmu Ilmu Perairan, Pesisir dan Perikanan 4 69-78
[17] Sahabudin U, Herawati D, Budi F S and Sulistono S 2017 Agrokreatif Jurnal Ilmiah Pengabadian kepada Masyarakat 3 60-70
[18] Browne M A et al. 2011 Environ. Sci. Technol. 45 9175-9
[19] Watts A J et al. 2014 Environ. Sci. Technol. 48 8823-30
[20] Boerger C M, Lattin G L, Moore S L and Moore C J 2010 Mar. Pollut. Bull. 60 2275-8
[21] Browne M A, Dissanayake A, Galloway T S, Lowe D M and Thompson R 2008 Environ. Sci. Technol. 42 5026-31
[22] Ningrum E W and Patria M P 2019 AIP Conf. Proc. 151 040002
[23] Ašmonaitė G and Almroth B C 2018 Effects of Microplastics on Organisms and Impacts on the Environment: Balancing the Known and Unknown (Sweden: University of Gothenburg)
[24] Cole M, Lindeque P K, Halsband C and Galloway T S 2011 Mari. Pollut. Bull. 62 2588–97
[25] Willis K, Hardesty B D, Kriwoken L and Wilcox C 2017 Sci. Rep. 7 1-9
[26] Zhang J C et al 2019 Mar. Pollut. Bull. 149 110569