OCEAN LIFE
Volume 2, Number 2, December 2018 E-ISSN: 2580-4529
Pages: 54-58 DOI: 10.13057/oceanlife/o0202xx

Measurement of microplastic density in the Karimunjawa National Park, Central Java, Indonesia

SULISTIYONO LIE[1,2,♥], AHMAD SUYOKO[1], AULIA ROMADHONA EFFENDI[2], BENARIFO AHMADA[2], HERDI WIRA ADITYA[2], ISTRIA RIMBA SALLIMA[2], NI PUTU AYU NITA ARISUDEWI[2], NAJLAA ILLIYYIEN HADID[1,2], NURULITA RAHMASARI[2], AKBAR REZA[3]

[1]Department of Tropical Biology, Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sinduadi, Mlati, Sleman 55281, Yogyakarta, Indonesia. Tel./fax.: +62-274-580839. ♥email: sulistiyonolie5@gmail.com
[2]Gadjah Mada Diving Society, Universitas Gadjah Mada. Gelanggang Mahasiswa UGM, Jl. Pancasila No. 1, Sleman 55281, Yogyakarta, Indonesia
[3]Laboratory of Ecology and Conservation, Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sinduadi, Mlati, Sleman 55281, Yogyakarta, Indonesia

Manuscript received: 7 October 2018. Revision accepted: 19 November 2018.

Abstract. *Lie S, Suyoko A, Effendi AR, Ahmada B, Aditya HW, Sallima IR, Arisudewi NPAN, Hadid NI, Rahmasari N, Reza A. 2018. Measurement of microplastic density in the Karimunjawa National Park, Central Java, Indonesia. Ocean Life 2: 54-58.* Plastic debris enters the marine ecosystem in various sizes, ranging from micrometers to millimeters. Specific densities of plastic particles can vary greatly depending on the type of polymer and the manufacturing process. The highest microplastic density is usually related to the shoreline and circulation of currents in the middle of the sea. Microplastics are then degraded into fragments or particles that are very small and digested by marine biota. In recent years, there have been increasing environmental concerns about microplastics. The purpose of this study was to determine the types of microplastics and their density in the Karimunjawa Island region, and to determine the environmental impact of microplastics. The method used was sediment sampling, with sand samples taken at a depth of 2-5 cm from the sand surface in a plot that was 10 meters away, with another plot in a 50-meter straight line. After that, microplastics were separated from sand samples in the laboratory using saturated saline solution. Next, the microplastics identification process was carried out by differentiating based on color, size, number, and microplastic form or category. In this study, four types of microplastic were found, i.e. fiber, fragment, film, and foam. At Legon Lele Beach and Ujung Gelam, fiber was the most abundant with 111 and 66 particles, respectively. The least in number was film- with 6 particles in Ujung Gelam Beach and 3 particles in Legon Lele Beach.

Keywords: Karimunjawa, microplastics, sand samples, sediment sampling

INTRODUCTION

The worldwide production of plastics has increased considerably since the development of synthetic polymers in the middle of the 20th century (Andrady 2011). When discarded into the marine environment, plastics can be an environmental hazard (Moore 2008). Plastic debris enters the marine ecosystem in a wide range of sizes, ranging from micrometer to millimeter (Barnes et al. 2009). In recent years, there has been increasing environmental concern about 'microplastics': tiny plastic granules used as scrubbers in cosmetics and air-blasting, and small plastic fragments derived from the breakdown of macroplastics (Derraik 2002). Microplastics have been attributed with numerous size-ranges, varying from study to study, with diameters of <10 mm, <5 mm, 2-6 mm, <2 mm (Ryan et al. 2009) and <1 mm (Claessens et al. 2011). This inconsistency is particularly problematic when comparing data referring to microplastics, making it increasingly important to create a scientific standard (Claessens et al. 2011, Costa et al. 2010).

Plastics manufactured to be of a microscopic size are defined as primary microplastics. These plastics are typically used in facial-cleansers and cosmetics, or as air-blasting media, whilst their use in medicine as vectors for drugs is increasingly reported (Patel et al. 2009). Secondary microplastics described as tiny plastic fragments are derived from the breakdown of larger plastic debris, both at sea and on land (Ryan et al. 2009, Thompson et al. 2004). Over time, a culmination of physical, biological and chemical processes can reduce the structural integrity of plastic debris, resulting in fragmentation (Browne et al. 2007).

Plastic debris on beaches, however, have high oxygen availability and direct exposure to sunlight so will degrade rapidly, in time turning brittle, forming cracks and ''yellowing'' (Moore 2008). With a loss of structural integrity, these plastics are increasingly susceptible to fragmentation resulting from abrasion, wave-action and turbulence (Browne et al. 2007). This process is ongoing, with fragments becoming smaller over time until they become microplastic in size (Ryan et al. 2009).

Whilst it is apparent that microplastics have become both widespread and ubiquitous, information on the biological impact of this pollutant on organisms in the marine ecosystem is only just emerging (Barnes et al. 2009). The possibility that microplastics pose a threat to biota, as their small size makes them available to a wide range of marine organisms, is of increasing scientific concern (Thompson et al. 2004). In addition to potential adverse effects from ingesting the microplastics themselves, toxic responses could also result from (i) inherent contaminants leaching from the microplastics, and (ii) extraneous pollutants, adhered to the microplastics, disassociating (Cole et al. 2011).

Karimunjawa Island is a coastal area that has an abundant fishery, and potential as a tourist destination. Microplastic marine waste may cause turmoil in the local community. Waste may pollute the coastal and marine areas. In addition, the absence of preliminary information about microplastic in this region is one of the obstacles to managing fisheries and marine potential based on environmentally-friendly technology. Based on this fact, a study needs to be done to find out the microplastic distribution on the sandy beaches in the Karimunjawa Islands region. Therefore, the purpose of this study was to determine the types of microplastic and their densities in the Karimunjawa Island region, and to determine the environmental impact of microplastics here.

MATERIALS AND METHODS

Study area

The study was carried out in the Karimunjawa Island (Karimunjawa National Park), Karimunjawa Sub-district, Jepara District, Central Java Province, Indonesia, i.e. (i) Legon Lele Beach, -5.8622312,110.4446497,17; and (ii) Ujung Gelam Beach, -5.8396515,110.4087674,17) (Figure 1).

Materials

In this study, the ingredients used were distilled water, aluminum foil, sand, saturated salt, filter paper, and paper tape.

Equiptment

Tools used were twine ropes, plastic containers, small shovels, beaker glasses, tweezers, nails, petri dishes, transects, scissors, stereo microscopes, and pencils.

Procedures and data analysis

Literature studies

A detailed literature review was conducted to identify the main methodological procedures that require standardization in sampling and extracting beach sand. We divided the findings into sampling procedures and extraction procedures. Data regarding variability in sampling procedures included: definition of microplastic size, beach zone sample, sample size, and sample depth. Data regarding variability in extraction procedures included: sample drying temperature/duration, completion time, number of re-extraction, and quantitative units. The sampling and extraction procedures were then analyzed and compared in terms of methodological variability.

Case studies

The design of the case study depends on a literature review. Thus, the main findings were collected here, and an outline of further findings was made in the results section. To determine whether and how much variation was identified in this literature, in sampling and extraction procedures influenced by the results of the study, case studies were carried out in the Karimunjawa Island National Park. Sand samples were taken from the high tide line at Legon Lele and Ujung Gelam beaches in the dry season April-May 2018. Sand samples were taken randomly on a straight line determined by a 50-meter transect with 5 plots separated by gaps of 10 meters.

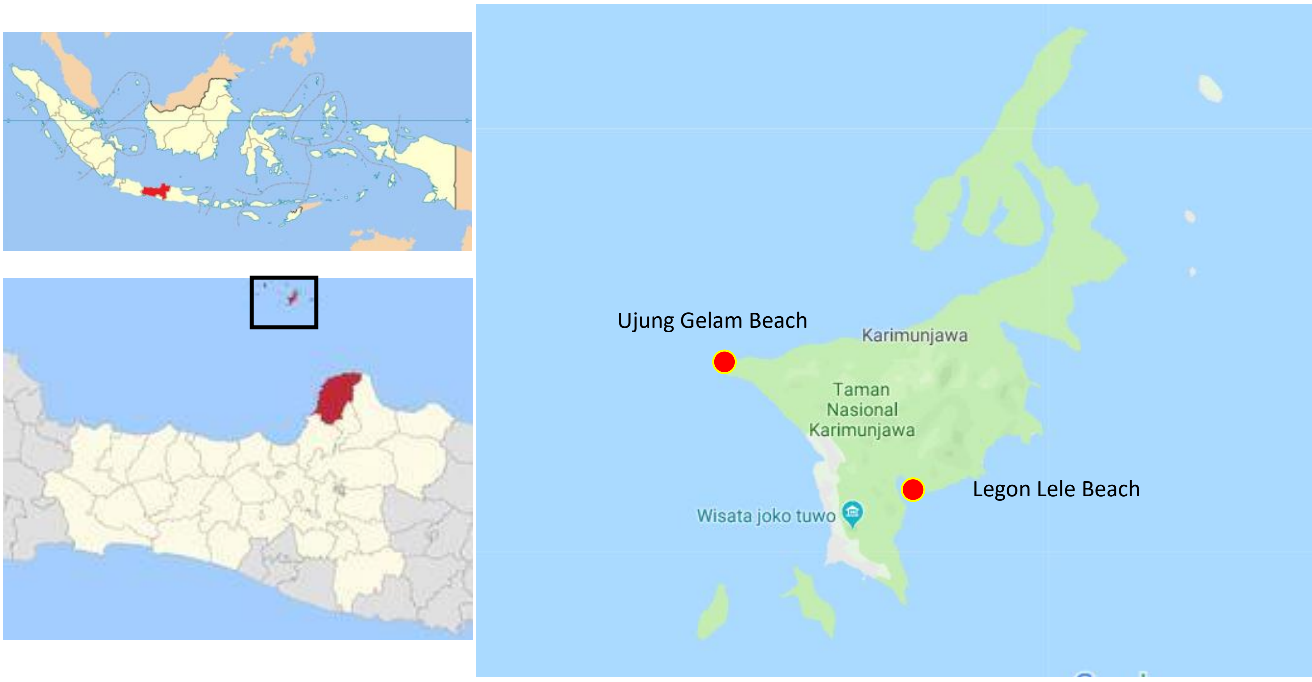

Figure 1. Study area in Karimunjawa Island, Jepara District, Central Java Province, Indonesia, i.e., Legon Lele Beach and Ujung Gelam Beach

Investigation of sampling procedures

Sampling was carried out using 30 × 30 cm squared sampling quadrat, which was placed at the sampling location. Sand samples were taken at a depth of 2-5 cm from the sand surface with a small shovel and inserted into a plastic container that had been coated with aluminum foil on the edges or walls in a closed container. A sample of 0.2-2 kg of sand per closed container was obtained from different plot points.

Investigation of extraction procedures

Sand was transported back to the laboratory, dried, and stored at room temperature until the extraction process. Microplastic in sand samples was extracted using saturated salt solution made by mixing distilled water with NaCl. Beach sand that had been mixed with saturated salt solution was then filtered with filter paper. Microplastic extraction was achieved by density separation. Microplastic quantities were calculated from sand samples taken from Legon Lele Beach and Ujung Gelam with a total of 10 sand samples on different filter paper. Filter paper was then examined under a stereo-microscope at up to 40-fold magnification and microplastic was calculated systematically, allowing for microplastic quantification in the range of 0.3-5 mm (NOAA, 2015). Based on the most commonly used definitions in the literature review, microplastic was defined as a plastic material smaller than 5 mm in the largest dimension. After that, the microplastic identification process was carried out by differentiating it based on color, size, number, and microplastic form or category. Microplastic density data were analyzed using Microsoft Excel.

RESULTS AND DISCUSSION

Based on this research, microplastic density was obtained by presenting the following data (Figure 2-5). In this study, four microplastic types consisting of fiber, fragments, films, and foam were found. These four types of microplastic were the most common in Legon Lele Beach and Ujung Gelam on Karimunjawa Island. The number of microplastic particles was sorted based on size. Microplastic particles of 1-5 mm in size were the most common in both sampling locations, Legon Lele Beach and Ujung Gelam. Microplastics with a size of 1-5 mm at Ujung Gelam Beach were found to be as many as 44 particles. Meanwhile, microplastic sizes of 1-5 mm in Legon Lele Beach were found to be as many as 62 particles.

In this study, the number of microplastic particles based on colors was sorted. Blue microplastic was the most common in both sampling points. A total of 101 microplastic particles were found at the Legon Lele Beach. Meanwhile, as many as 51 blue microplastic particles were found at the Ujung Gelam Beach.

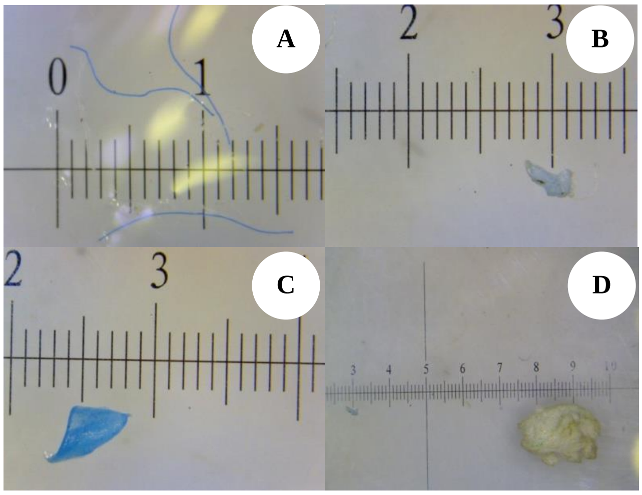

Figure 2. Microplastic types: (A) fiber, (B) fragments, (C) films, (D) foam found in Legon Lele Beach and Ujung Gelam, Karimunjawa Island, Central Java, Indonesia

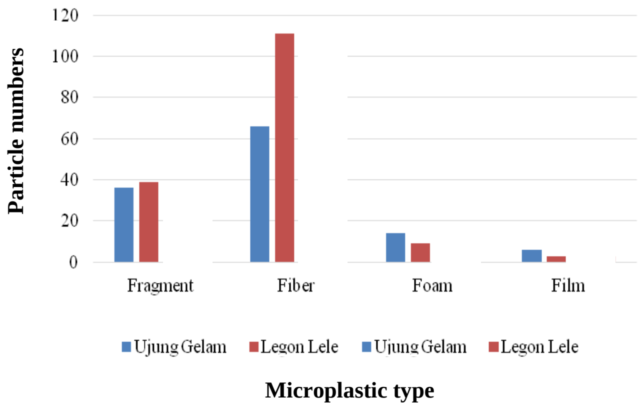

Figure 3. Types and densities of microplastics found in Karimunjawa Island, Central Java, Indonesia

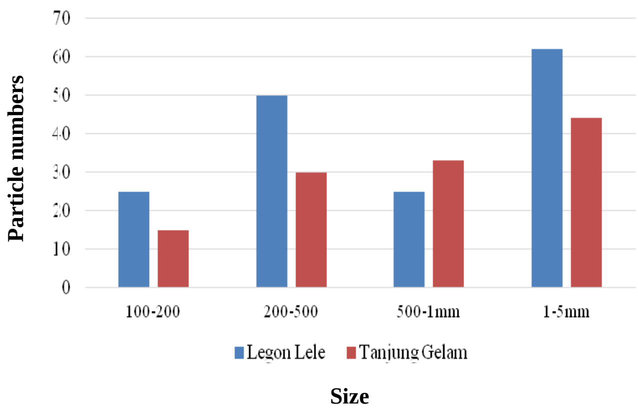

Figure 4. Sizes and particle numbers of microplastics in Karimunjawa Island, Central Java, Indonesia

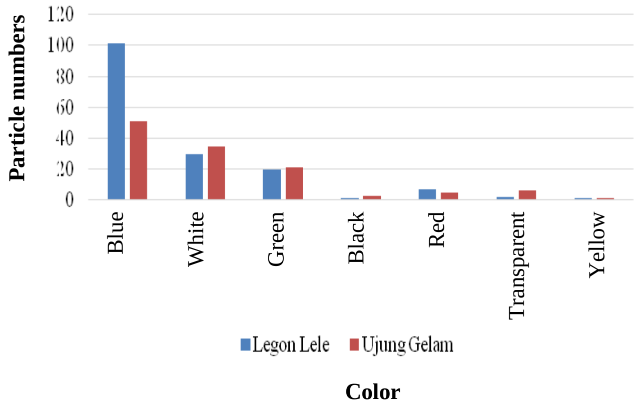

Figure 5. Colors and particle numbers of microplastics in Karimunjawa Island, Central Java, Indonesia

Discussion

In this study, four microplastic types consisting of fiber, fragments, films, and foam had been found. A plastic factory in the vicinity of the study area was absent so that no pellets were found in this study. According to Kingfisher (2011), pellets are the primary microplastic directly produced by factories as raw material for the manufacture of plastic products. Microplastic density of fiber type was in the highest order. After fiber, there were sequential types of microplastic fragments, foam, and films. Fragments are the result of cutting plastic products with very strong synthetic polymers (Kingfisher 2011), films have a density lower than fiber so that they are easily transported (Hastuti 2014) and fiber is derived from fishing activities. Fiber can come from high fishing activity around the area so that it contributes debris to seawater (Katsanevakis and Katsarou 2004). Fragments are derived from plastic consumer products. The origins of these fragments can be in the form of fishing nets, fiber lines (polypropylene strands), industrial raw materials (for example, from the ship breaking industry), polymer fragments of plastics can be decomposed by oxidation. Other specific microplastic sources such as small facial cleansers and microplastic polyethylene or low-density polyester fibers may eventually reach the sea. Our findings are in line with previous studies, where there were no clear distribution patterns of microplastics found at different sampling sites (Besley et al. 2016).

Specific density of plastic particles can vary greatly depending on the type of polymer and the manufacturing process. The density values for plastics range from 0.8 to 1.4 g cm^{-3}, specifically for polypropylene are from 0.85 to 0.94 g cm^{-3}, polyethylene are from 0.92 to 0.97 g cm^{-3}, and for polystyrene are from <0.05 to 1.00 g cm^{-3}. These values refer to pure resin, without taking into account the effects of the density of various additives that may be added during the manufacture of the product. The general density for sand or other sediments is 2.65 g cm^{-3}. This difference is used to separate plastic particles that are lighter than heavier sediment or sand grains by mixing sediment samples with saturated solutions and shaking them for a period of time. After mixing, the sediments are expected to quickly settle down, while low-density particles remain in suspension or float to the surface of the solution (Hidalgo-Ruz et al. 2012). Microplastic characteristics determine the distribution and impact in the environment. For example, solid plastic particles spend more time in contact and collide more strongly with abrasive sedimentary particles than do lighter microplastic ones. This difference is important because it can affect the level of degradation, surface characteristics, and shape of microplastic particles. There is no minimum size set for microplastic. The smallest size reported is 1 µm in diameter and 20 µm in length in sediment samples. Most studies show values above 500 µm for sediment samples and 300 µm for seawater samples. This differentiation depends directly on two main factors: the tools used during sampling and processing steps. More than 500 µm of particles are stored in filters and standard cans then sorted using a surgical microscope. Less than 500 µm particles are usually only obtained by research with separation of density and filtration, and particles less than 2 µm are not possible to be represented in a representative manner (Browne et al. 2010). Color can facilitate separation in situations where microplastic is spread among a large number of other debris. Eye-catching color particles have a high probability of being isolated for subsequent identification as microplastic, while those with dull colors are easily forgotten, so they have the potential to cause bias. Color has also been used as a photodegradation index and residence time at sea level. The process of discoloration (yellowing) shows a longer exposure time to seawater, which increases the likelihood of the polymer being oxidized (Frias et al. 2010).

In general, microplastics move differently from macroplastic at sea: macroplastic distributions can often be explained by prevailing currents and winds, while mechanisms encouraging microplastic distribution are less known and may be affected by particle aggregation or animal activity. Comparative studies should be carried out to determine the dynamics of microplastic accumulation along wave exposure gradients and tidal height. Studies from subtidal zones reveal that microplastics are more abundant in subtidal sediments than on sandy beaches and in estuary habitats (Browne et al. 2011).

Marine food chains generally involve these organisms (with order symbolized by the arrow): phytoplankton → zooplankton → small fishes → large fishes. Since most of the plankton are microscopic, microplastics may be mistakenly eaten as food by the larger organisms such as fishes. Sizes of particles categorized as microplastics have not yet been properly defined. Some say microplastics may be as large as 5 mm (Cole 2011). The size is larger than most plankton. Generally, the size of phytoplankton falls under 35 um, and the size of zooplankton is between 35-157 µm (nauplii and rotifers) or above 157µm (exclusively copepods and cladocerans) (Kim et al. 2000). Proof of microplastic ingestion by zooplankton has been documented. Desforges et al. (2015) reported that *Neocalanus cristatus*, a copepod consumed microplastics with an enconter rate of one particle/every 34 copepods analyzed (0.026 ± 0.005 particles/individual zooplankton) and *Euphausia pacifia*, an euphausiid, with an encounter rate of one particle/every 17 euphausiids (0.058 ± 0.01 particles/zooplankton). Cole et al. (2013) shows that the ingestion may be size-independent such as in *Centropages typicus* and *Temora longicornis* that consumed 7.3, 20.6, and 30.6 µm polystyrene beads, size-dependent such as in *Acartia clausi* that ingested 7.3 µm beads but ingested significantly fewer 20.6 and 30.6 µm beads, and *Calanus helgolandicus* that showed significantly less affinity for 30.6 µm beads than for 7.3 µm beads, life-stage selective such as in decapod Brachyurans where brachyuran zoea showed no affinity for 20.6 µm beads, while the more developed brachyuran megalopa readily ingested such beads, or individually selective such as in *Obelia* sp., Paguridae larvae, and Porcellinidae (zoea). Cole et al. (2013) also reported that the rate of algal feeding was reduced in copepods due to microplastics. This may be caused by the clogging of zooplankton's alimentary canal.

In conclusion, based on the research that has been done, it can be concluded that there are four types of microplastic found i.e. fiber, fragment, film, and foam. In this study, the most abundant microplastic type found was fiber at both sampling points, namely Legon Lele Beach and Ujung Gelam. Microplastic particles of 1-5 mm in size were the most common in both sampling locations. Blue microplastic was the most common at both sampling points. Food chains of marine organisms involve several organisms. Because most planktons are microscopic, microplastic may be eaten by large organisms such as fish. The rate of algal consumption is also reduced in the microplastic copepods. The highest microplastic abundance is usually related to the coastline and circulation of currents in the middle of the sea. Microplastics are then degraded into fragments or particles that are very small and digested by marine biota.

REFERENCES

Andrady AL. 2011. Microplastics in the marine environment. Mar Pollut Bull 62: 1596-1605.

Barnes DKA, Galgani F, Thompson RC, Barlaz M. 2009. Accumulation and fragmentation of plastic debris in global environments. Philos Trans R Soc B 364: 1985-1998.

Besley A, Martina G, Vijver, Paul B, Thijs, Bosker. 2016. A standardized method for sampling and extraction methods for quantifying microplastics in beach sand. Mar Pollut Bull 2: P. 7-8.

Browne MA, Galloway T, Thompson R. 2007. Microplastic - an emerging contaminant of potential concern?. Integr Environ Assess Manag 3: 559-561.

Browne MA, Galloway TS, Thompson RC. 2010. Spatial patterns of plastic debris along estuarine shorelines. Environ Sci Technol 44, 3404-3409.

Browne MA, Crump P, Niven SJ, Teuten EL, Tonkin A, Galloway T, Thompson RC. 2011. Accumulations of microplastic on shorelines worldwide: sources and sinks. Environ Sci Technol 45: 9175-9179.

Costa M, Ivar do Sul J, Silva-Cavalcanti J, Araújo M, Spengler Â, Tourinho P. 2010. On the importance of size of plastic fragments and pellets on the strandline: a snapshot of a Brazilian beach. Environ Monit Assess 168: 299-304.

Cole M, Lindeque P, Halsband C, Galloway SC. 2011. Microplastics as contaminants in the marine environment: a review. Mar Pollut Bull 62: 2588-2597.

Cole M, Lindeque P, Fileman E, Halsband C, Goodhead R, Moger J, Galloway TS. 2013. Microplastic ingestion by zooplankton. Environ Sci Technol 47: 6646-6655.

Claessens M, Meester SD, Landuyt LV, Clerck KD, Janssen CR. 2011. Occurrence and distribution of microplastics in marine sediments along The Belgian coast. Mar Pollut Bull 62: 2199-2204.

Derraik JGB. 2002. The pollution of the marine environment by plastic debris: a review. Mar Pollut Bull 44: 842-852.

Desforges W, Jean-Pierre, Galbraith M, Ross PS. 2015. Ingestion of microplastics by zooplankton in the Northeast Pacific Ocean. Arch Environ Contam Toxicol 69:320-330.

Frias JPGL Sobral P, Ferreira AM. 2010. Organic pollutants in microplastics from two beaches of the Portuguese coast. Mar Pollut Bull 60: 1988-1992.

Hastuti AR. 2014. Distribusi Spasial sampah laut di ekosistem mangrove Pantai Indah Kapuk Jakarta. Departemen Manajemen Sumber Daya Perairan Fakultas Perikanan dan Ilmu Kelautan Institut Pertanian Bogor, Bogor.

Hidalgo-Ruz V, Lars Gutow, Richard C. Thompson, Martin, Thiel. 2012. Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification. Environ Sci Technol 46, 3060-3075.

Katsanevakis S, Katsarou A. 2004. Influences on the distribution of marine debris on the seafloor of shallow coastal areas in Greece (Eastern Mediterranean). Water Air Soil Pollut 159: 325-337.

Kim, Hyun-Woo, Hwang, Soon-Jin, Joo, Gea-Jae. 2000. Zooplankton grazing on bacteria and phytoplankton in a regulated large river (Nakdong River, Korea). J Plankton Res 22(8): 1559- 1577.

Kingfisher J. 2011. Micro-plastic debris accumulation on puget sound beaches. Port Townsend Marine Science Center [Internet]. :http://www.ptmsc.org/Science/plastic_project/Summit%20 Final%20Draft.pdf.

Moore CJ. 2008. Synthetic polymers in the marine environment: a rapidly increasing, long-term threat. Environ Res 108: 131-139.

Patel MM, Goyal BR, Bhadada SV, Bhatt JS, Amin AF. 2009. Getting into the brain: approaches to enhance brain drug delivery. CNS Drugs 23: 35-58.

Ryan PG, Moore CJ, van Franeker JA, Moloney CL. 2009. Monitoring the abundance of plastic debris in the marine environment. Phil Trans R Soc B: Biol Sci 364: 1999-2012.

Thompson RC, Olsen Y, Mitchell RP, Davis A, Rowland SJ, John AWG, McGonigle D, Russell AE. 2004. Lost at sea: where is all the plastic? Science 838.