Microplastic occurrence in Venus clam *Marcia hiantina* (Veneridae) in Tallo Estuary, Makassar, Indonesia

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Abstract. Microplastic pollution is already a global concern. Due to improper solid waste management, plastic waste will end up in the ocean. Tallo Estuary is a primary habitat of Venus clam (*Marcia hiantina*), one of the fisheries commodities in Makassar City, Indonesia. The existence of microplastic could harm the food security of *M. hiantina*. This study aims to determine the abundance and characteristics of microplastics in *M. hiantina* collected from Tallo Estuary. Microplastic from *M. hiantina* was extracted using the KOH digestive method. *M. hiantina* collected from Tallo Estuary was confirmed to contain microplastic, with an average abundance ranging from 1.10 to 3.08 item individual^{-1}. The contamination level of microplastic in *M. hiantina* ranged from 60 to 83.33%. The dominant microplastic shape was line microplastic. Large microplastic (1-5 mm) has a larger proportion than small microplastics (<1 mm) in *M. hiantina* samples. The community, stakeholders and government must pay more attention to microplastic pollution in Tallo Estuary to prevent more severe situations in the future.
Key Words: Bivalvia, coastal, Indonesia, plastic, riverine, shellfish.

Introduction. Plastics is currently one of the most common materials produced by humans, after cement and steel (Geyer et al 2017). Plastics are widely used because of their flexibility and durability. However, since it was commercialized in the 1950s, the current global plastic production continues to increase, having reached up to 350 million tons in 2018 (PlasticsEurope 2019). Due to improper solid waste management, this condition leads to plastic leakage into the ocean (Jambeck et al 2015; Lestari & Trihadiningrum 2019). Most plastic waste will end up in the ocean through riverine and estuarine areas (Lebreton et al 2017). The existence of plastic debris in the aquatic environment can have a negative impact on aquatic organisms.

Plastic debris in the environment can also break down into smaller pieces due to physical abrasion and chemical stressors (Corcoran et al 2009; O'Brine & Thompson 2010). The small pieces of plastic with a size under 5 mm are grouped into a term called microplastics (MPs) (Thompson et al 2004; Frias & Nash 2019). Currently, MPs receive increased attention from researchers, governments and policy makers due to their environmental impacts. MPs could be ingested by the aquatic organisms and release the toxic compounds that exist internally, such as plastic additives and adsorbed chemicals from the environment (Dris et al 2015; Rochman 2015). This condition can lead to adverse effects on aquatic organisms. Aquatic organisms of the class Bivalvia can heavily be affected by MPs (Li et al 2019).

Bivalvia, in general, are known as filter-feeder organisms that are mostly immobile in their habitat. Because of their immovability, they tend to represent the condition of aquatic pollution in their habitat, being good sentinel organisms (Su et al 2018; Li et al 2019). The accumulation of MPs by bivalvia has often been observed worldwide. Mussels (*Mytilus galloprovincialis*) for human consumption in the Mediterranean Lagoon were reported to contain MPs up to 12 items individual^{-1} (Wakkaf et al 2020). Pacific oysters (*Crassostrea gigas*) from Halfmoon Bay also contain MPs up to 0.6 items individual^{-1} (Rochman et al 2015). Asian clams (*Corbicula fluminea*) collected from the Yangtze River basin can accumulate MPs up to 5 items individual^{-1} (Su et al 2018). If the accumulation of MPs and toxic compounds in clams continues to happen, it will threaten food security and human health (Barboza et al 2018).

Venus clam (*Marcia hiantina*) is a common consumption commodity in Makassar City, Indonesia. Makassar City is one of the places in Indonesia proven to be polluted by MPs. MPs of different colors were found in the Makassar Coastal area (Afdal et al 2019). The Tallo Estuary, as the primary habitat of *M. hiantina* in Makassar City, is also known to be a hotspot of MPs (World Bank Group 2018; Wicaksono et al 2020, 2021). Due to the contaminated habitat, *M. hiantina* in Tallo Estuary accumulates MPs from the environment. This condition can cause *M. hiantina* consumption to threaten the health of the consumers. The purpose of this study is to identify the abundance of MPs in *M. hiantina* individuals from the Tallo Estuary, Indonesia. The abundance of MPs in the estuary water was also examined to determine whether it affects the MPs abundance in *M. hiantina*.

Material and Method. Clam and water samples were collected from the Tallo Estuary, Makassar City, Indonesia, in August 2019. A total of 22 *M. hiantina* individuals (12 individuals from the estuary, which is the first sampling location, and 10 individual from the Lakkang site, which is the second location) and 6 water samples (3 samples from each site) were collected (Figure 1). The estuary represented the location influenced directly by the marine environment, while Lakkang was chosen as a location closer to the Tallo river body. *M. hiantina* were collected from the substrate sediment at each sampling point and placed into a coolbox. The length of clams was measured using calipers (±0.1 mm) and the wet weight was measured using digital scales (±0.01 g). The clam soft tissue was then placed in the sample containers and, 20% KOH solution was added. KOH solution is an adequate solution to digest organic matter and prevent the destruction of MPs polymers (Lusher et al 2017). The clam samples were left until all the clam soft tissue was digested. Samples were then observed visually using a 45× magnification stereomicroscope for MPs identification.

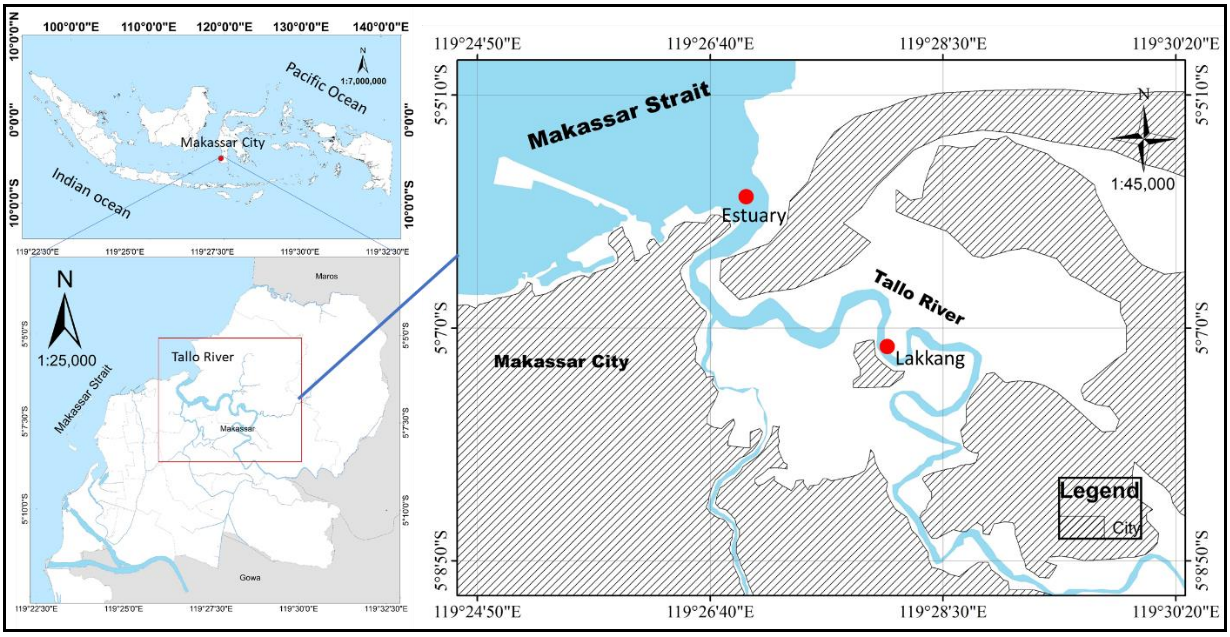

Figure 1. Location of the sampling sites.

Water samples were collected using the protocol suggested by Wicaksono et al (2020). An approximate 1 m^2 rectangle mouth-size neuston net was towed for 100 m in triplicate in each sampling point. Water left (±300 mL) in the net cod-end was moved to the laboratory and filtered using 0.45 μm cellulose paper. The filter paper was allowed to dry at room temperature and was observed using a stereomicroscope for MPs identification.

MPs abundance was reported in item individual^{-1} for *M. hiantina* samples and item m^{-3} for water samples. The volume of water filtered during towing (m^3) was calculated by multiplying the net mouth wide with the towing distance. Microplastic contamination level in *M. hiantina* was calculated by comparing the number of individual containing MPs to the total number of individuals. MPs contamination level is expressed in percentage (%). MPs shape classification refers to GESAMP (2019), dividing MPs shapes into line, fragment, film, foam, and pellet. A parametric t-test was used to analyze the difference of MPs abundance in the water samples between Lakkang and estuary sites. The non-parametric Mann Whitney test was used to compare MPs abundance in *M. hiantina* between two areas due to abnormality data distribution. MPs shape and size were presented in the proportion graphic to compare MPs characteristics between Lakkang and Estuary sites.

Results and Discussion. The characteristics of *M. hiantina* collected in this research are described in Table 1.

Table 1

Characteristics and MPs contamination level of *M. hiantina* in each sampling sites

Sampling site	*No of samples*	*Mean total length±SD (cm) (range)*	*Mean total wet weight±SD (g) (Range)*	*MPs contamination level*
Estuary	12	4.32±0.91 (2.24–5.24)	22.92±10.47 (6.41–34.62)	83.33%
Lakkang	10	4.81±0.37 (4.27–5.37)	27.22±4.74 (19.25–34.5)	60%

Note: SD - standard deviation; MPs - microplastics.

In general, clams collected from the Lakkang site were bigger based on total length and total wet weight than clams collected from the estuary. The MPs contamination level in *M. hiantina* in the estuary is higher (83.33%) compared to the Lakkang (60%) site. In general, MPs abundance in *M. hiantina* is also higher in the estuary (3.08±4.16 item individual^{-1}) compared that from Lakkang (1.10±1.1 item individual^{-1}). However, there were no significant differences between the sites based on the Mann-Whitney test ($P>0.05$) (Figure 2).

Based on MPs abundance, clams from the estuary may contain 3 times more MPs than clams from Lakkang site. This suggests that MPs contamination in *M. hiantina* is more severe in the estuary than in Lakkang. The presence of MPs in clams is currently known to have negative impacts. MPs have been reported to cause abnormalities in the gills and digestive tract of *M. galloprovinciallis* (Alnajar et al 2021). MPs can also lead to inflammatory response, histological alterations and abnormalities in filtering activity of bivalves (Li et al 2019). These physiological disturbances can affect the homeostasis, which will lead to inhibited growth.

Based on our results, the MPs abundance in water samples has a similar pattern with MPs abundance found in *M. hiantina*. MPs abundance in water from the estuary (3.41±0.13 item m^{-3}) is significantly higher compared to that found in the Lakkang site (2.00±0.22 item m^{-3}) ($p<0.01$) (Figure 2). This indicates that the MPs abundance in *M. hiantina* samples might be influenced by the abundance of MPs in water samples. MPs abundance in the estuary area is usually influenced by the gradient surrounding anthropogenic activities (Hitchcock & Mitrovic 2019). The MPs in the estuary water can accumulate in clams through filter-feeding activity. Once the MPs enter the clam, MPs can release toxic substances that can have negative impacts on the organism (Cole et al 2011). Toxic substances can also transfer to higher trophic levels and threaten humans as clam consumers (Barboza et al 2018).

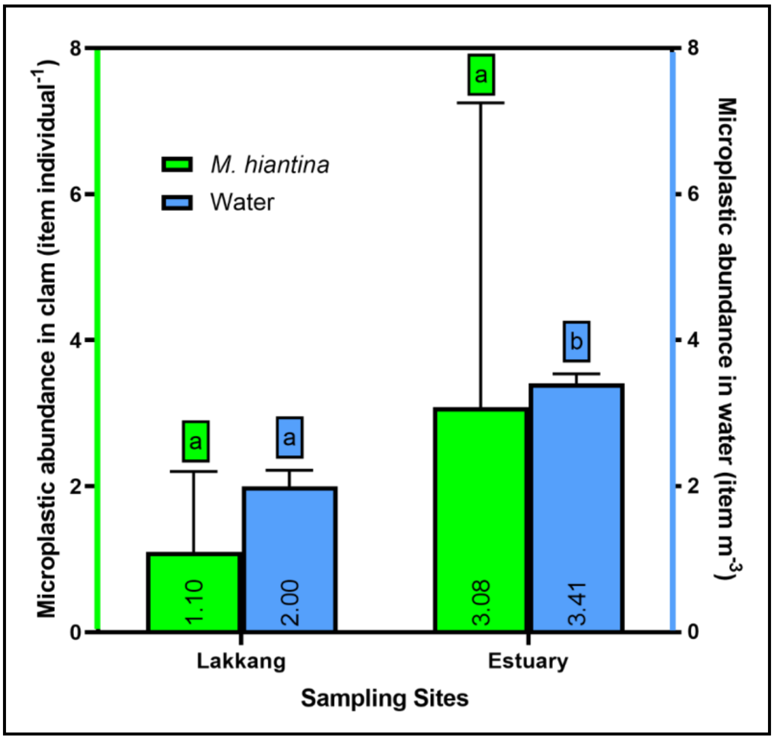

Figure 2. Microplastics abundance in *Marcia hiantina* and water in sampling sites.

Based on MPs shape, *M. hiantina* tend to accumulate line MPs (86.49-100%). In contrast, the predominant MPs shape in the water is fragment MPs (50–59.26%) (Figure 3).

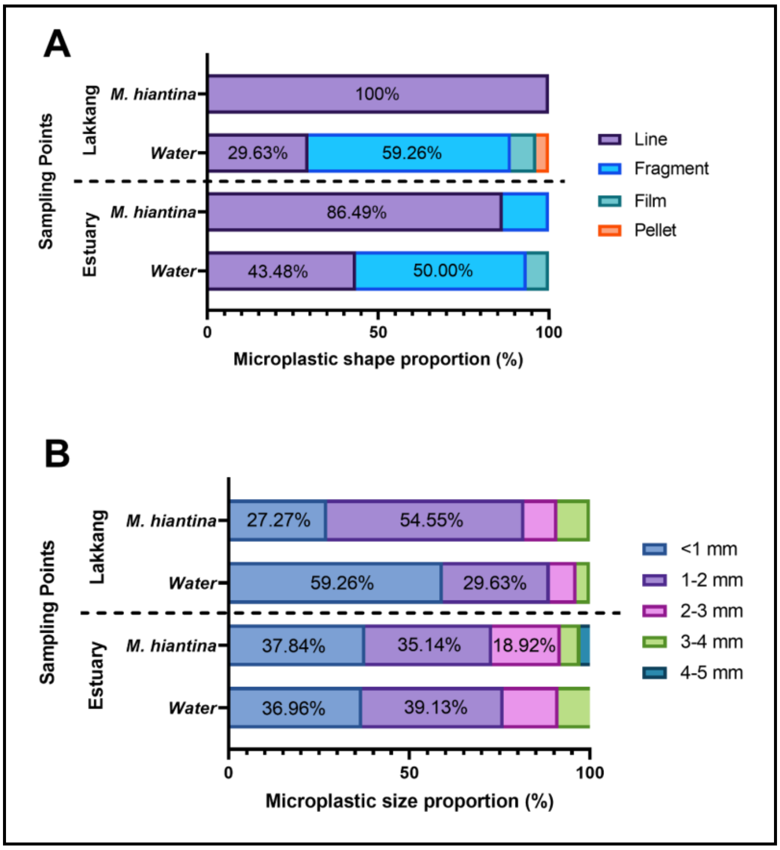

Figure 3. Microplastics shape (A) and size (B) proportion in *Marcia hiantina* and water samples.

This result suggests that *M. hiantina* tend to uptake more line MPs than fragment MPs. Unlike fish, clams, as filter-feeders, have no selectivity in MPs uptake. Fish may have selectivity in MPs uptake because most fish find their prey using visual senses (McNeish et al 2018). It has been reported that fish tend to ingest light-color plastic (Crawford & Quinn 2016; Wicaksono et al 2020). However, due to the absence of visual sense in clams, there is no MPs selectivity based on color. The clams may have a MPs selectivity based on MPs' shape. The high abundance of line MPs in clams might be because of the nature of line MPs. Line MPs in Tallo River are mostly dominated by rayon and polyester polymer (Wicaksono et al 2021). In general, these polymers have a higher density compared to seawater (GESAMP 2019). This condition causes the line MPs to end up at the bottom of the water column and in the sediment, which is the habitat of *M. hiantina*, make it more bioavailable to *M. hiantina*.

MPs in *M. hiantina* have a similar size proportion with MPs from the water (Figure 3). MPs in both compartments were dominated by the MPs in sizes under 2 mm. This similar profile suggests that the MPs accumulated in *M. hiantina* originated from the water compartment. MPs can be divided into two main groups, the large MPs (1-5 mm) and small MPs (<1 mm) (Rodríguez-Seijo & Pereira 2017; Lestari et al 2020). MPs found in *M. hiatnina* mostly consist of large MPs (40.74– 72.73%). MPs can be translocated between mussel organs at a size up to 10 μm (Browne et al 2008). The larger MPs will mostly end up in the bivalve feces rather than in tissue (Van Cauwenberghe et al 2015). This suggests that the most large MPs in *M. hiantina* will be excreted. Although physical MPs were excreted, the potential dangers of toxic substances from MPs still pose a threat to *M. hiantina*.

This study provides an overview of MPs occurrence in clams collected from the Tallo Estuary. The presence of MPs in clams in the Tallo Estuary should be an early warning against MPs pollution in Makassar City, considering this is not the first report of MPs occurrence in aquatic organisms from this location (Bahri et al 2020; Wicaksono et al 2020).

Conclusions. Microplastics were found in *M. hiantina* and water samples from Tallo Estuary. *M. hiantina* collected from the location closer to the marine environment tend to have more MPs (3.08 item individual^{-1}) compared to those located closer to the river body (1.10 item individual^{-1}). The MPs contamination level in *M. hiantina* from the Lakkang site was 60%, while in the estuary site was 83.33%. Lines was the most dominant MPs shape found in the *M. hiantina* samples (86.49-100%). The community, stakeholders and government must pay more attention regarding MPs pollution in the Tallo Estuary to prevent more severe situations in the future.

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Conflict of Interest. The authors declare that there is no conflict of interest.

References

Afdal M., Werorilangi S., Faizal A., Tahir A., 2019 Studies on microplastics morphology characteristics in the coastal water of Makassar City, South Sulawesi, Indonesia. International Journal of Environment, Agriculture and Biotechnology 4(4):1028-1033.

Alnajar N., Jha A. N., Turner A., 2021 Impacts of microplastic fibres on the marine mussel, *Mytilus galloprovinciallis*. Chemosphere 262:128290, 7 p.

Bahri A. R. S., Ikhtiar M., Baharuddin A., Abbas H. H., 2020 Identification of microplastic in tilapia fish (*Oreochromis mossambicus*) at Tallo River in Macassart. International Journal of Science and Healthcare Research 5(3):406-411.

Barboza L. G. A., Vethaak A. D., Lavorante B. R. B. O., Lundebye A. K., Guilhermino L., 2018 Marine microplastic debris: An emerging issue for food security, food safety and human health. Marine Pollution Bulletin 133:336-348.
Browne M. A., Dissanayake A., Galloway T. S., Lowe D. M., Thompson R. C., 2008 Ingested microscopic plastic translocates to the circulatory system of the mussel, *Mytilus edulis* (L.). Environment Science & Technology 42(13):5026-5031.
Cole M., Lindeque P., Halsband C., Galloway T. S., 2011 Microplastics as contaminants in the marine environment: A review. Marine Pollution Bulletin 62(12):2588-2597.
Corcoran P. L., Biesinger M. C., Grifi M., 2009 Plastics and beaches: A degrading relationship. Marine Pollution Bulletin 58(1):80-84.
Crawford C. B., Quinn B., 2016 Microplastic pollutants. Elsevier, 336 p.
Dris R., Imhof H., Sanchez W., Gasperi J., Galgani F., Tassin B., Laforsch C., 2015 Beyond the ocean: contamination of freshwater ecosystems with (micro-)plastic particles. Environmental Chemistry 12(5):539-550.
Frias J. P. G. L., Nash R., 2019 Microplastics: Finding a consensus on the definition. Marine Pollution Bulletin 138:145-147.
Geyer R., Jambeck J. R., Law K. L., 2017 Production, use, and fate of all plastics ever made. Science Advances 3(7):e1700782, 6 p.
Hitchcock J. N., Mitrovic S. M., 2019 Microplastic pollution in estuaries across a gradient of human impact. Environmental Pollution 247:457-466.
Jambeck J. R., Geyer R., Wilcox C., Siegler T. R., Perryman M., Andrady A., Narayan R., Law K. L., 2015 Plastic waste inputs from land into the ocean. Science 347(6223):768-771.
Lebreton L. C. M., van der Zwet J., Damsteeg J. W., Slat B., Andrady A., Reisser J., 2017 River plastic emissions to the world's oceans. Nature Communications 8:15611, 10 p.
Lestari P., Trihadiningrum Y., 2019 The impact of improper solid waste management to plastic pollution in Indonesian coast and marine environment. Marine Pollution Bulletin 149:110505, 9 p.
Lestari P., Trihadiningrum Y., Wijaya B. A., Yunus K. A., Firdaus M., 2020 Distribution of microplastics in Surabaya River, Indonesia. Science of the Total Environment 726:138560, 9 p.
Li J., Lusher A. L., Rotchell J. M., Deudero S., Turra A., Bråte I. L. N., Sun C., Shahadat Hossain M., Li Q., Kolandhasamy P., Shi H., 2019 Using mussel as a global bioindicator of coastal microplastic pollution. Environmental Pollution 244:522-533.
Lusher A. L., Welden N. A., Sobral P., Cole M., 2017 Sampling, isolating and identifying microplastics ingested by fish and invertebrates. Analytical Methods 9:1346-1360.
McNeish R. E., Kim L. H., Barrett H. A., Mason S. A., Kelly J. J., Hoellein T. J., 2018 Microplastic in riverine fish is connected to species traits. Scientific Reports 8:11639, 12 p.
O'Brine T., Thompson R. C., 2010 Degradation of plastic carrier bags in the marine environment. Marine Pollution Bulletin 60(12):2279-2283.
Rochman C. M., 2015 The complex mixture, fate and toxicity of chemicals associated with plastic debris in the marine environment. In: Marine anthropogenic litter. Bergman M., Gutow L., Klages M. (eds), Springer International Publishing, Cham, pp. 117-140.
Rochman C. M., Tahir A., Williams S. L., Baxa D. V., Lam R., Miller J. T., Teh F. C., Werorilangi S., Teh S. J., 2015 Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. Scientific Reports 5:14340, 10 p.
Rodríguez-Seijo A., Pereira R., 2017 Morphological and physical characterization of microplastics. In: Comprehensive analytical chemistry: Characterization and analysis of microplastics. Rocha-Santos T. A. P., Duarte A. C. (eds), Elsevier, pp. 49-66.
Su L., Cai H., Kolandhasamy P., Wu C., Rochman C. M., Shi H., 2018 Using the Asian clam as an indicator of microplastic pollution in freshwater ecosystems. Environmental Pollution 234:347-355.

Thompson R. C., Olson Y., Mitchell R. P., Davis A., Rowland S. J., John A. W. G., McGonigle D., Russell A. E., 2004 Lost at sea: Where is all the plastic? Science 304(5672):838.
Van Cauwenberghe L., Claessens M., Vandegehuchte M. B., Janssen C. R., 2015 Microplastics are taken up by mussels (*Mytilus edulis*) and lugworms (*Arenicola marina*) living in natural habitats. Environmental Pollution 199:10-17.
Wakkaf T., El Zrelli R., Kedzierski M., Balti R., Shaiek M., Mansour L., Tlig-Zouari S., Bruzaud S., Rabaoui L., 2020 Microplastics in edible mussels from a southern Mediterranean lagoon: Preliminary results on seawater-mussel transfer and implications for environmental protection and seafood safety. Marine Pollution Bulletin 158:111355, 7 p.
Wicaksono E. A., Tahir A., Werorilangi S., 2020 Preliminary study on microplastic pollution in surface-water at Tallo and Jeneberang Estuary, Makassar, Indonesia. AACL Bioflux 13(2):902-909.
Wicaksono E. A., Werorilangi S., Galloway T. S., Tahir A., 2021 Distribution and seasonal variation of microplastics in Tallo River, Makassar, Eastern Indonesia. Toxics 9(6): 129, 13 p.
*** GESAMP, 2019 Guidelines for the monitoring and assessment of plastic litter in the ocean. Kershaw P. J., Turra A., Galgani F. (eds), IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, Rep. Stud. GESAMP, 123 p.
*** PlasticsEurope, 2019 Plastics - the facts 2019 : An analysis of European plastics production, demand and waste data. The Association of Plastics Manufacturers in Europe, The European Association of Plastics Recycling and Recovery Organisations, 42 p.
*** World Bank Group, 2018 Indonesia marine debris hotspot rapid assessment: Synthesis report. World Bank Group, Washington D.C., 46 p.

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