

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/358897430>

Floating microplastics on the sea surface of semi- closed and open bays of small islands

Article in *AACL Bioflux* · February 2022

CITATION

1

READS

133

6 authors, including:



[Rafidha Dhuha Ahmad Opier](#)

National Research and Innovation Agency (BRIN) Indonesia

12 PUBLICATIONS 25 CITATIONS

SEE PROFILE

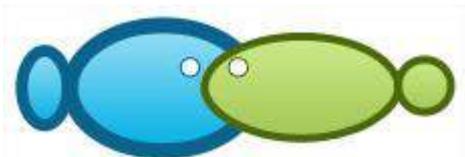


[Suyadi Suyadi](#)

Indonesian Institute of Sciences

45 PUBLICATIONS 558 CITATIONS

SEE PROFILE



Floating microplastics on the sea surface of semi-closed and open bays of small islands

¹Corry Y. Manullang, ¹Rafidha D. A. Opier, ²Suyadi, ¹Irwan Rehalat, ¹Ahmad Soamole, ¹Willem M. Tatipatta

¹ Research Center for Deep Sea, National Research and Innovation Agency, Ambon, Indonesia; ² Research Center for Biology, National Research and Innovation Agency, Bogor, Indonesia. Corresponding author: C. Y. Manullang, corr001@brin.go.id

Abstract. The lack of proper waste management systems leads to plastic pollution in marine waters, especially in semi-closed and open bays. Ambon Bay is located in a small island, comprising the Inner Ambon Bay (IAB) and the Outer Ambon Bay (OAB). The objective of this study was to assess floating microplastics (MPs) in both semi-closed bay (e.g. IAB) and open bay (e.g. OAB). The study showed that MPs concentration in the Ambon Bay had a mean value of 0.1632 n L^{-1} . The Kruskal-Wallis analysis ($\chi^2(1)=7.75$, $p=0.011$) showed that the concentration of MPs in the semi-closed bay (IAB) was significantly higher (58%, with a mean of 0.3292 n L^{-1}) than in the OAB (8%, with a mean of 0.0437 n L^{-1}). Fibers were the most common MPs (86%), followed by films (13%) and fragments (1%). Most fibers were distributed in the IAB (93%), while fragments were distributed mostly in the OAB (63%) and films were distributed equally in the IAB and OAB. The MPs concentration in Ambon Bay was higher than in other bays in the world. This is an alert signal of plastic pollution, especially in semi-closed bays. It was confirmed that plastic pollution negatively affects the ecosystem (e.g. mangrove), marine biota and health. This data and information is required for a better co-management of the waste and of the coastal area of bays.

Key Words: microplastic, sea surface, semi-closed, open bay, Ambon Bay.

Introduction. Plastics represent an important element of the scope of materials used in recent society. Plastics have a lot of advantages over other materials such as irons or metals. Owing to the advantages of plastic, such as being less expensive, strong, lightweight and adjustable, nearly all human needs are based on plastic. Plastics are widespread in industries such as: construction, transportation, electrical and electronic, packaging, automotive, sports, furniture, medicals and healthcare, etc. The largest usage of plastics worldwide is related to the numerous packaging applications, such as food packaging, containers, bottles, boxes, cups and vending packaging, baby products and protective packaging. The plastic used in packaging applications is mostly disposable (Thevenon & Carroll 2015).

The inadequate of waste management in the coastal nations led to million tons of plastic thrown in the ocean (Jambeck et al 2015; Meijer et al 2021; Geyer et al 2017; Napper & Thompson 2020; Ostle et al 2019). Marine plastic debris can enter the marine environment by riverine transport, sewage overflow, leisure activities on beach or at sea and by the wind (Veiga et al 2016). In the marine environment waters, plastics can slowly break down in smaller pieces, due to the physical, chemical and biological factors. The plastic with a size of less than 5 mm is called microplastic (Gesamp 2015).

The presence of microplastics (MPs) has been reported in sea water, sediment and marine biota from all types of marine ecosystems, like: coral reef (Hall et al 2015; Patti et al 2020), seagrass (Tahir et al 2019,2020; Jones et al 2020), mangrove (Patria et al 2020; Cordova et al 2021), bays (McEachern et al 2019), estuarines (Zhao et al 2014; Bikker et al 2020), beaches (Manullang 2019; Jeyasanta et al 2020), open ocean (Desforges et al 2015; Kanhai et al 2018) and deep-sea floor (Van Cauwenberghe et al 2013; Peng et al 2018). Microplastics are found close to urban and industrialized areas,

such as Hong Kong (Tsang et al 2017), but also in remote areas close to the Arctic (Lusher et al 2015).

This study was focused on Ambon Bay. The Ambon Bay is part of the Ambon Island, an urban area in the eastern part of Indonesia. Ambon Bay is divided into two parts, namely the Inner Ambon Bay (IAB) and the Outer Ambon Bay (OAB). The IAB is a semi-closed bay, relatively small (total area is 2.5 km²), with shallow waters (average depth: 26 m) and low water currents (Anderson & Sapulette 1981). Meanwhile, the OAB is a relatively open water, connected to the Banda Sea, larger than the IAB, with deep waters (average: 100 m) and high water currents (0.19 m s⁻¹) (Fadli & Radjawane 2014). Furthermore, the IAB was separated by a narrow and shallow sill (Figure 1). The aim of this study was to provide the preliminary assessment of floating MPs in the sea surface of the Ambon Bay. There have been other studies on MPs around Ambon Bay (Manullang 2019; Tuhumury & Pellaupessy 2021), but they didn't provide data about concentrations in the sea surface around the Bay. The present research could be a comparative reference for the studies of marine MPs in the future.

Material and Method

Sea surface water samples were collected in September 2019. Six transect line samplings were conducted around the Ambon Bay: 2 in the IAB (Poka-Galala (PG) and Waiheru-Halong (WH)), 1 in the sill area (Merah Putih Brigde (MPB)) between the IAB and the OAB, and 3 in the OAB (Airport-Eri (AE), Hative Besar-Salobar (HBS) and Wayame-Mardika (WM)) using a manta net with a 15 x 25 cm² opening and a 200 µm mesh. The manta net was towed along the surface layer, at a nominal speed of 2-3 knots, for 10-15 minutes, in each transect. The towing off was performed on the port side of the boat, to avoid the disturbance by the bow wave. The net and cod end were rinsed thoroughly with clean seawater for any potential MPs. The geographical position of the start and end of each tow was recorded. A flow meter was attached to the subsurface net frame near the mouth of the net and the number of revolutions of the flow meter were recorded. The seawater volumes filtered through the net ranged from 1,746 to 21,829 per line transect. Once the towing was completed, the net was rinsed into the cod end. The content of the net was washed into a sample glass jar.

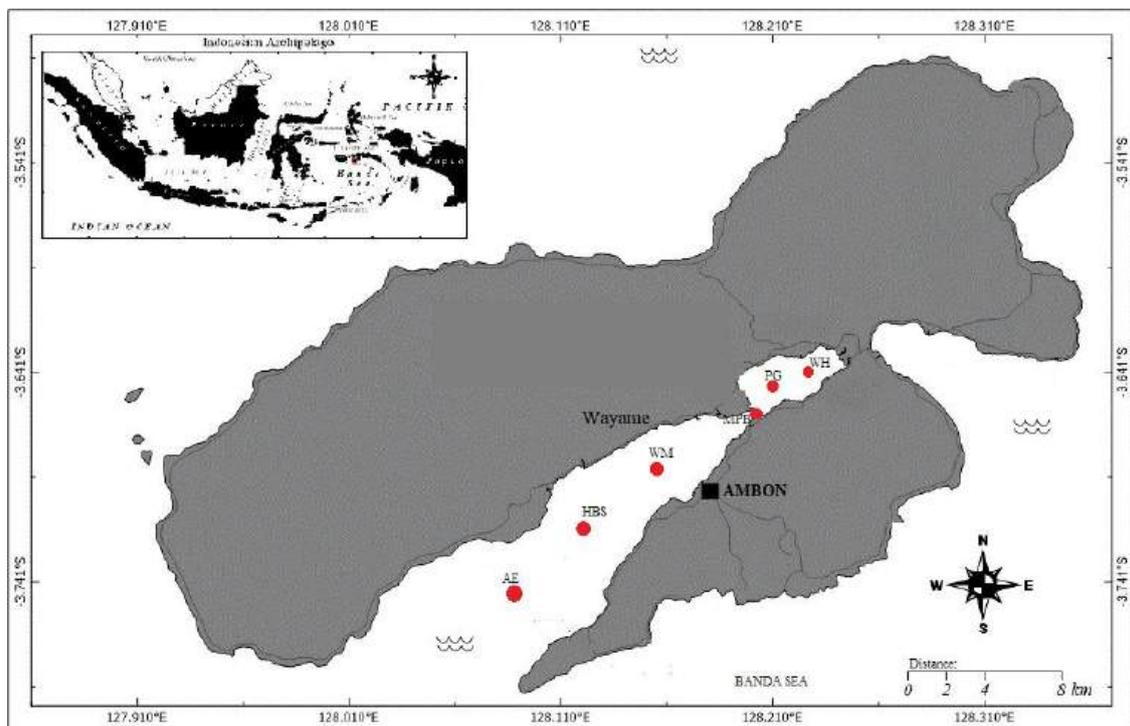


Figure 1. Sampling location sites.



Figure 2. Manta net with a 15 x 25 cm² opening and a 200 µm mesh (original photo).

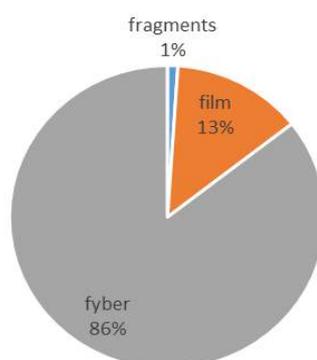
In the laboratory, samples were left to dry at 40°C. To remove organic matter, 30 mL of 30% H₂O₂ solution were added and then heated at 40°C (Masura et al 2015). If any natural organic matter remained, an additional amount of 30% H₂O₂ was added to the samples, repeatedly. After no natural organic remained, the H₂O₂ solution was eliminated using a sieve with a mesh size of 0.037 µm. The samples were collected in a beaker and then NaCl solution was added. The sample was then moved to a density separator, covered with an aluminium foil and then left for 24 h. After 24 h, the floating MPs were extracted using a sieve mesh size of 0.037 µm. Thereafter, the contents of each sieve were analyzed under a dissecting microscope to count the MPs found. In this study, we counted all the MPs with a size <100 µm. Plastic particles were classed into fragments, fibers, films and pellets. The concentration of MPs found was performed in items per liter (n L⁻¹). A Kruskal-Wallis test, followed by a Bonferroni post-hoc test, were applied to determine if significant differences in MPs occurred between the IAB, sill area and OAB.

Results. The study confirmed that floating microplastic were found at all sites of study area: IAB, sill area, and OAB. A Kruskal-Wallis analysis $\chi^2(1)=7.75$, $p=0.011$) showed that concentration of MPs in the IAB (with a mean of 0.3292 n L⁻¹) was significantly higher than in the OAB (with a mean of 0.0437 n L⁻¹, $p=0.002$) and in the sill area (with a mean of 0.1901 n L⁻¹, $p=0.002$). About 58% of MPs were distributed in the IAB, 34% in the sill area and only 8% in the OAB. The MPs concentration in the IAB was ranging from 0.2252 to 0.4331 n L⁻¹, in the sill area it was of 0.1901 n L⁻¹ and in OAB it was ranging from 0.0146 to 0.0821 n L⁻¹ (Table 1). The largest abundance of MPs was in WH (0.4331 n L⁻¹), located in the IAB, followed by the MPB (sill area), and the lowest was in WM (0.0146 n L⁻¹), located in the OAB (Table 1).

Table 1
Floating MPs concentration on sea surface of Outer Ambon Bay (OAB), Sill area, and Inner Ambon Bay (IAB)

Site	Location	Coordinates				Vol (L)	MPs concentration (n L ⁻¹)			
		Start		End			Fragment	Film	Fiber	Total
		Long	Lat	Long	Lat					
AE	OAB	3.71	128.10	3.74	128.12	21,829	0.0022	0.0207	0.0115	0.0344
HBS	OAB	3.67	128.14	3.70	128.16	12,418	0.0039	0.0420	0.0362	0.0821
WM	OAB	3.68	128.17	3.69	128.18	11,323	0.0004	0.0059	0.0082	0.0146
MPB	sill area	3.66	128.20	3.66	128.20	1,746	0.0023	0.0412	0.1466	0.1901
PG	IAB	3.64	128.19	3.66	128.20	7,496	0.0005	0.0112	0.2134	0.2252
WH	IAB	3.65	128.22	3.63	128.22	13,578	0.0010	0.0102	0.4219	0.4331

Fibers (86%), films (13%) and fragments (1%), were found in all sites, but differently distributed among the bay (Figure 3). About 63% of the fragments were distributed in the OAB and 37% were distributed in the IAB. In contrast, the fibers were mainly distributed in the IAB (93%) and only 7% were distributed in the OAB. Films were distributed almost equally: 48% in the IAB and 52% in the OAB. The most common type of MPs, namely the fibers, come from the intensive fishing activities (Katsanevakis & Katsarou 2004). Fragments are the result of cutting plastic products with very strong synthetic polymers (Kingfisher 2011). Previous studies conducted in the Ambon Bay found a high abundance of fiber type plastics in the fish from the Ambon Bay and plastic film stranded on the beach and in the mangrove ecosystems (Tuhumury & Pellaupessy 2021; Manullang 2019; Suyadi & Manullang 2020a).



Shape of microplastics in the study area

Figure 3. The shape of MPs in the Ambon Bay.

Discussion. The higher MPs concentration found in the IAB might be related to the difference in water currents and bathymetry between the IAB and OAB. The oceanography studies have been estimated that the water mass which enters the IAB from Banda Sea (OAB) will be trapped for about 17 hours in the IAB (Anderson & Sapulete 1981). It is also considered that MPs will remain longer in the IAB. A previous study in Ambon Bay also proved that MPs concentration on the beaches of the IAB was higher than on the beaches of the OAB (Manullang 2019).

Compared to other semi-closed bays in the world, Ambon Bay was the most polluted by MPs (Table 2). Mean MPs concentration in Ambon Bay (0.1632 n L^{-1}) was much higher than in the Chesapeake Bay in USA (0.00016 n L^{-1}) and Jiaozhou Bay in China (0.046 n L^{-1}) (Bikker et al 2020; Zheng et al 2019). The highest concentration of MPs was in the IAB. The MPs concentration in the OAB was lower than in the Jiaozhou Bay (China), but it was much higher than in the Chesapeake Bay (USA), Tokyo Bay (Japan), Tampa Bay (USA) and Xiangshan Bay (China) (Table 2).

The result of this study indicates that marine waters are being polluted by MPs at an alarming rate in semi-closed bays such as Ambon Bay. Plastic pollution also occurred in the coastal area, such as in the mangrove ecosystem of the Ambon Bay (Suyadi & Manulang 2020a). Plastic pollution has negative impacts on the mangrove health and seedlings survival (Suyadi & Manulang 2020a). It was confirmed that MPs pollution contaminated marine biota and caused outbreaks of diseases, due to microbial colonization by pathogens (Lamb et al 2018; Choy et al 2019). In turn, these affected the human health, for example, it was recorded that 30 people got diarrhea and 4 of them died after consuming mollusks collected from the bay (Sapulete et al 2007; Suyadi 2009).

The high MPs concentration in the Ambon Bay far exceeds the values measured in other semi-closed bays, due to poor waste management systems in the urban area, around the bay. About $150 \text{ tons day}^{-1}$ of litter was produced in the Ambon Bay and 38% of it goes to the ocean, especially in the Ambon Bay (Suyadi & Manulang 2020b). Ambon Island is one of the most populated small islands in Indonesia, with a population density of over $647 \text{ people km}^{-2}$ (BPS 2015). Most of the population is living in the coastal areas, especially around the Ambon Bay (Suyadi 2012). Many physical infrastructures are

located in the coastal areas, such as settlements, traditional and modern markets, harbor, oil and electrical infrastructures, and airport. These anthropogenic activities contribute to the high plastic pollution in the Ambon Bay.

Plastic pollution on the coastal ecosystem and in the marine waters of small islands, such as Ambon, may be higher than around large islands. This is due to a limited carrying capacity of the island and to a lack of facilities and of a waste management system. Plastic debris did not only pollute the urban area and its surrounding marine waters, but also the rural area (even uninhabited islands) and its surrounding marine waters (Suyadi et al 2021a,b). Based on data of the Ministry of Industry, for the year 2017, it is estimated that around 4.8 million tons of plastic pollution has been mismanaged in Indonesia (Republic of Indonesia-Indonesia's Plan of Action on Marine Plastic Debris (NPAP) 2017). 9% or about 620.000 tons of them were released into the water bodies (rivers, lakes and ocean). The latest report of the World Bank in 2021 has been updated to 4.9 million tons (World Bank 2021). Furthermore, it has to be mentioned that most of the mismanaged plastic pollution in Indonesia comes from the urban areas or small-medium cities (e.g. Ambon). Meanwhile, in the USA or Japan, where waste management system are more adequate, over 90% of their waste is already managed (Nakano et al 2021).

Table 2

Comparison MPs concentration found in the Ambon Bay and in other bays

<i>Location</i>	<i>Country</i>	<i>Mean MPs concentration (n L⁻¹)</i>	<i>Reference</i>
Inner Ambon Bay (IAB)	Indonesia	0.3292	This study
Outer Ambon Bay (OAB)	Indonesia	0.0437	This study
Ambon Bay (IAB + OAB)	Indonesia	0.5630	This study
Tokyo Bay	Japan	0.00055	Nakano et al 2021
Chesapeake Bay	USA	0.00016	Bikker et al 2020
Tampa Bay, Florida	USA	0.0045	McEachern et al 2019
Jiaozhou Bay	China	0.046	Zheng et al 2019
Xiangshan Bay	China	0.0089	Chen et al 2018

Conclusions. The semi-closed bay (Inner Ambon Bay-IAB, with a mean of 0.3292 n L⁻¹) was more polluted by floating MPs than the open bay (OAB). About 58% of the MPs were distributed in the IAB. Semi-closed bays, especially in small islands, such as the IAB, are vulnerable, being characterized by shallow waters, narrow straits and slow water circulation. Consequently, MPs are trapped and remain in the bay for a longer time, with long-term negative impacts on ecosystems, marine biota and health. The MPs concentration in the Ambon Bay was much higher than in other semi-closed bays in the world. This is an alert signal of plastic pollution in marine waters and coastal ecosystems (bays). Given the high plastic pollution, dramatic decisions have to be taken and an effective co-management of waste and coastal (bay) is required to reduce plastic pollution and to improve the quality of marine waters.

Acknowledgements. The authors would like to thank the Indonesian Institute of Sciences (aka National Research and Innovation Agency) for funding this study and LIPI COREMAP-CTI 2021–2022 (17/A/DK/2021) for funding the processing charges.

Conflict of interest. The authors declare no conflict of interest.

References

Anderson J. J., Sapulette D., 1981 Deep water renewal in inner Ambon Bay, Ambon, Indonesia. Proceedings of the Fourth International Coral Reef Symposium 1:369–374.

- Bikker J., Lawson J., Wilson S., Rochman C. M., 2020 Microplastics and other anthropogenic particles in the surface waters of the Chesapeake Bay. *Marine Pollution Bulletin* 156:111257.
- Chen M., Jin M., Tao P., Wang Z., Xie W., Yu X., Wang K., 2018 Assessment of microplastics derived from mariculture in Xiangshan Bay, China. *Environmental Pollution* 242:1146–1156.
- Choy C. A., Robinson B. H., Gagne T. O., Erwin B., Firl E., Halden R. U., Hamilton J. A., Katija K., Lisin S. E., Rolsky C., Van Houtan K. S., 2019 The vertical distribution and biological transport of marine microplastics across the epipelagic and meopleagis water column. *Scientific Reports* 9:7843.
- Cordova M. R., Ulumuddin Y. I., Purbonegoro T., Shiomoto A., 2021 Characterization of microplastics in mangrove sediment of Muara Angke Wildlife Reserve, Indonesia. *Marine Pollution Bulletin* 163:112012.
- Desforges J. P. W., Galbraith M., Ross P. S., 2015 Ingestion of microplastics by zooplankton in the Northeast Pacific Ocean. *Archives of Environmental Contamination and Toxicology* 69(3):320–330.
- Fadli M., Radjawane I. M., 2014 [Hydrodynamic modelling in Ambon Bay]. *Prosiding PIT* 1(1):6-19. [In Indonesian].
- Geyer R., Jambeck J. R., Law K. L., 2017 Production, use, and fate of all plastics ever made. *Science Advances* 3(7):1700782.
- Hall N. M., Berry K. L. E., Rintoul L., Hoogenboom M. O., 2015 Microplastic ingestion by scleractinian corals. *Marine Biology* 162(3):725–732.
- Jeyasanta K. I., Sathish N., Patterson J., Edward J. K. P., 2020 Macro-, meso- and microplastic debris in the beaches of Tuticorin district, Southeast coast of India. *Marine Pollution Bulletin* 154:111055.
- Jones K. L., Hartl M. G. J., Bell M. C., Capper A., 2020 Microplastic accumulation in a *Zostera marina* L. bed at Deerness Sound, Orkney, Scotland. *Marine Pollution Bulletin* 152:110883.
- Kanhai L. D. K., Gårdfeldt K., Lyashevskaya O., Hassellöv M., Thompson R. C., O'Connor I., 2018 Microplastics in sub-surface waters of the Arctic Central Basin. *Marine Pollution Bulletin* 130:8–18.
- Lamb J. B., Willis B. L., Florenza E. A., Couch C. S., Howard R., Rader D. N., True J. D., Kelly L. A., Ahmad A., Jompa J., Harvell C. D., 2018 Plastic waste associated with disease on coral reefs. *Science* 359:460–462.
- Lusher A. L., Tirelli V., O'Connor I. R., 2015 Officer microplastics in Arctic polar waters: the first reported values of particles in surface and sub-surface samples. *Scientific Reports* 5:14947.
- Manullang C. Y., 2019 The abundance of plastic marine debris on beaches in Ambon Bay. *IOP Conference Series: Earth and Environmental Science* 253(1):1-6.
- Masura J., Baker J., Foster G., Arthur C., 2015 Laboratory methods for the analysis of microplastics in the marine environment. *NOAA Marine Debris National Program*, pp. 1–39.
- McEachern K., Alegria H., Kalagher A. L., Hansen C., Morrison S., Hastings D., 2019 Microplastics in Tampa Bay, Florida: Abundance and variability in estuarine waters and sediments. *Marine Pollution Bulletin* 148:97–106.
- Napper I. E., Thompson R. C., 2020 Plastic debris in the marine environment: history and future challenges. *Global Challenges* 4(6):1900081.
- Ostle C., Thompson R. C., Broughton D., Gregory L., Wootton M., Johns D. G., 2019 The rise in ocean plastics evidenced from a 60-year time series. *Nature Communications* 10(1):1-6.
- Patria M. P., Santoso C. A., Tsabita N., 2020 Microplastic ingestion by periwinkle snail *littoraria scabra* and mangrove crab *Metopograpsus quadridentata* in Pramuka Island, Jakarta Bay, Indonesia. *Sains Malaysiana* 49(9):2151–2158.
- Patti T. B., Fobert E. K., Reeves S. E., Burke da Silva K., 2020 Spatial distribution of microplastics around an inhabited coral island in the Maldives, Indian Ocean. *Science of the Total Environment* 748:141263.

- Peng X., Chen M., Chen S., Dasgupta S., Xu H., Ta K., Du M., Li J., Guo Z., Bai S., 2018 Microplastics contaminate the deepest part of the world's ocean. *Geochemical Perspectives Letters* 9:1–5.
- Sapulete D., Mudjiono, Pelasula D., 2007 Laporan monitoring Teluk Ambon 2007. *Konservasi Biota Laut Ambon-Lembaga Pengetahuan Indonesia, Ambon*, pp. 5–15.
- Suyadi, Manullang C. Y., 2020a Distribution of plastic debris pollution and its implications on mangrove vegetation. *Marine Pollution Bulletin* 160:111642.
- Suyadi, Manullang C. Y., 2020b Conservation of marine biological resources: Challenges and management. *Proceeding of PIT ISOI 2019*.
- Suyadi, 2009 The condition of mangrove forest in Ambon Bay: prospect and challenges. *Berita Biologi* 9(5):481–490.
- Suyadi, 2012 A decade of mangrove forest condition in Ambon Bay, Maluku. *Jurnal Biologi Indonesia* 8(1):197–203
- Suyadi, Prayudha B., Renyaan J., Indrabudi T., Manulang C. Y., Naro I., 2021a Mangrove in the urban area of small islands: Vegetation health, potential, and management challenges. *IOP Conference Series: Earth and Environmental Science* 789(1):012012.
- Suyadi, Nugroho D. A., Irawan A., Pelasula D., Ruli F., Islami M. M., Alik R., Naro I., 2021b Biodiversity in the coastal ecosystems of small islands and its conservation status. *IOP Conference Series: Earth and Environmental Science* 762(1):012024.
- Tahir A., Samawi M. F., Sari K., Hidayat R., Nimzet R., Wicaksono E. A., Asrul L., Werorilangi S., 2019 Studies on microplastic contamination in seagrass beds at Spermonde Archipelago of Makassar Strait, Indonesia. *Journal of Physics: Conference Series* 1341(2):1–6.
- Thevenon F., Carroll C., 2015 Plastic debris in the ocean: the characterization of marine plastics and their environmental impacts, situation analysis report. IUCN, Global Marine and Polar Programme, <https://doi.org/10.2305/iucn.ch.2014.03.en>.
- Tsang Y. Y., Mak C. W., Liebich C., Lam S. W., Sze E. T., Chan K. M., 2017 Microplastic pollution in the marine waters and sediments of Hong Kong. *Marine Pollution Bulletin* 115(1–2):20–28.
- Tuhumury N. C., Pellaupessy H. S., 2021 [Identification of the presence of microplastics in *Caranx sexfasciatus* cultivated in the inner Ambon Bay]. *Journal Sumberdaya Akuatik Ondopasifik* 5(1):47–54. [In Indonesian].
- Van Cauwenberghe L., Vanreusel A., Mees J., Janssen C. R., 2013 Microplastic pollution in deep-sea sediments. *Environmental Pollution* 182:495–499.
- Veiga J. M., Fleet D., Kinsey S., Nilsson P., Vlachogianni T., Werner S., Galgani F., Thompson R. C., Dagevos J., Gago J., Sobral P., Cronin R., 2016 Identifying sources of marine litter. MSFD GES TG marine litter thematic report JRC Technical Report, 44 p.
- Zhao S., Zhu L., Wang T., Li D., 2014 Suspended microplastics in the surface water of the Yangtze Estuary System, China: first observations on occurrence, distribution. *Marine Pollution Bulletin* 86:562–568.
- Zheng Y., Li J., Cao W., Liu X., Jiang F., Ding J., Yin X., Sun C., 2019 Distribution characteristics of microplastics in the seawater and sediment: a case study in Jiaozhou Bay, China. *Science of the Total Environment* 674:27–35.
- *** BPS, Badan Pusat Statistik, 2015 Population of Province Maluku by Regency/City, 1961–2020, <http://maluku.bps.go.id/linkTabelStatis/view/id/179>
- *** GESAMP, 2015 Sources, fate, and effects of microplastics in the marine environment: a global assessment. IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. GESAMP No. 90:96.
- *** Republic of Indonesia, 2017 Government Republic of Indonesia, Indonesia's Plan of Action on Marine Plastic Debris (NPAP), 2017–2025. Jakarta, Indonesia.
- *** World Bank, 2021 Plastic waste discharges from rivers and coastlines in Indonesia. *Marine Plastics Series, East Asia, and Pacific Region*. Washington DC.

Received: 29 September 2021. Accepted: 07 February 2022. Published online: 21 February 2022.

Authors:

Corry Yanti Manullang, Research Center for Deep Sea, National Research and Innovation Agency, 97233 Ambon, Molucca, Indonesia, e-mail: corr001@brin.go.id

Rafidha Dh Ahmad Opier, Research Center for Deep Sea, National Research and Innovation Agency, 97233 Ambon, Molucca, Indonesia, e-mail: viviopier@gmail.com

Suyadi, Research Center for Biology, National Research and Innovation Agency, 16911, Bogor, Indonesia, e-mail: pedhetsuyadi@gmail.com

Irwan Rehalat, Research Center for Deep Sea, National Research and Innovation Agency, 97233 Ambon, Molucca, Indonesia, e-mail: irwa003@lipi.go.id

Ahmad Soamole, Research Center for Deep Sea, National Research and Innovation Agency, 97233 Ambon, Molucca, Indonesia, e-mail: ahma018@lipi.go.id

Willem Merpy Tatipatta, Research Center for Deep Sea, National Research and Innovation Agency, 97233 Ambon, Molucca, Indonesia, e-mail: wm.tatipatta@gmail.com

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

How to cite this article:

Manullang C. Y., Opier R. D. A., Suyadi, Rehalat I., Soamole A., Tatipatta W. M., 2022 Floating microplastics on the sea surface of semi-closed and open bays of small islands. *AAFL Bioflux* 15(1):454-461.