ABUNDANCE AND COMPOSITION OF MARINE DEBRIS IN SOUTH MISOOL, RAJA AMPAT DISTRICT, WEST PAPUA

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ABSTRACT
Marine debris has become a huge threat to marine ecosystems; one of them is Misool, Raja Ampat Marine Reserve, West Papua. Anthropogenic activities are the main contributor of marine debris. This research aims to identify and determine the abundance and composition of marine debris and factor affecting them in Misool, Raja Ampat. Macrodebris samples were collected and categorized by composition and color. Meso- and microdebris samples were extracted from water and sediments with a filtration and floatation method using concentrated NaCl solution and later identified based on its structure and color. Results show that density of macro-, meso-, and microdebris are higher in

villages than in conservation area, except in high tide, macro- & mesodebris density is higher in ocean surface on conservation area than in village. It is caused by ocean current. Composition of the marine debris is dominated by plastic, reaching 91% of macrodebris & 100% of meso- & microdebris. Single-used plastic are commonly found. Meso- & microdebris structure seen on this research are foam, fragment, filament, and film. The predominant shades of macro-, meso-, and microdebris colors are bright. The absence of a proper waste management at the villages also contributes to debris abundance.

Keywords: Marine debris, conservation area, Raja Ampat, plastic

1. Introduction

Marine debris has been seen as a problem since 1987. Marine debris is waste that intentionally or unintentionally comes to marine environment (Lippiat et al., 2013), in the forms of organic or non-organic compounds that are difficult to or cannot be composed. Forms of marine debris can be found in the form of whole materials (plastic bottle, slippers, fabrics, nets and others), macro-fragment (> 2,5 cm), meso-fragment (0,5 - 2,5 cm), and micro-fragment (< 0,5 cm). These materials are produced by human activities.

Human activities in land or marine environments, habits of throwing waste in carelessly, and less of household waste management can be the main cause of the existence of marine debris (Zhao et al., 2014; Duhec et al., 2015; Syakti et al., 2017; Indonesia Marine Debris Hotspot, 2018; Andrady, 2011). Current, waves, and gusts of wind are the factors giving influences on distribution of waste even to remote areas (Duhec et al., 2015; Zhou et al., 2015; Andrades et al., 2018).

Marine debris can act as transporter of invasive organisms from one area to others, reducing biodiversity in the polluted ecosystem (Gall & Thompson, 2015; UNEP, 2014). Marine debris which is ingested by organisms can carry poison which can be accumulated (UNEP, 2014). There are a number of cases of death of animals by eating or being twisted by marine debris. Examples of the cases are the death of Larson Albatros bird child living in Atoll Kure, Hawaii since it ate waste, and a turtle that found out to be twisted by a net in Caribbean, Karibia (Gall & Thompson, 2015). Fish stock can also be decreased by lack of survival and reproductive ability caused by consumption of marine debris (Beaumont et al., 2019).

Tourism sector also affected since marine debris lower aestheticism of one tourism area. Tourists also have a tendency to avoid any dirty tourism resorts, and they also less prefer spending time in dirty areas (Beaumont et al., 2019). It can also cause tourists to be injured, caused by being stuck or twisted by nets. Misool, Raja Ampat, Papua Barat, having status as Marine

Protected Area of Marine Tourism Park (MPA) is also facing this threat.

The existence of settlement and community activities such as transportation, fishing, and tourism gives impacts of marine debris on Misool area. Initial survey taken by Bestari (2019, unpublished data) show the existence of inorganic macro and micro waste in coastal and marine areas in the utilization zone including food security and tourism sub-zones. This shows that areas that are far from the village also have the potential to be contaminated with waste. There are not many or published data related to composition of debris in MPA areas of nearby settlement, in fact the areas surrounding the settlement commonly includes as Sustainable Fisheries Zone (sustainable fisheries and *sasi* sub-zones as well as sustainable aquaculture and fishery sub-zones). Marine debris does not only have an effect on tourism but also fish stock in Misool.

This study aims to study pollution by marine debris, seen from the structure (form) and composition (type) of marine debris found in the southern Misool MPA, which is located near and further from the village. Locations close to the villages are sustainable fisheries zones, while those that are far away are utilization zones. Misool MPA will be greatly influenced by the presence of debris on coastal and marine environments because the presence of debris makes the environment dirty and unattractive for tourists. Biota survival such as turtles and fish as well as fish stock in the MPA is certainly affected by debris that pollutes the coastal and marine environments. This data is expected to be useful as data for the government, community, and actors in the Misool MPA regarding pollution caused by marine debris so that it can become the basis for increasing the effectiveness of waste handling in Misool and also other areas in Indonesia.

2. Research Methodology

2.1. Study Area

This research was conducted in the South Misool Marine Protected Area (MPA), Raja Ampat. This area is managed by *UPTD BLUD KKP* Raja Ampat. The area reaches 336,000 hectares, consisting of three zoning: Core Zone, Sustainable Fisheries Zone, and Utilization Zone. The Sustainable Fisheries Zone is further divided into two sub-zones, namely Aquaculture and Sustainable Fisheries sub-zone, and *Sasi* and Traditional Utilization sub-zones. The Utilization Zone is divided into Food Security and Tourism sub-zones.

The research was carried out in settlement areas including South Misool district, called Yaganaan, Yalapale, and Dabatan villages which are included in the sustainable fisheries zone (sasi sub-zone and sustainable fisheries as well as sustainable aquaculture and fisheries) and the MPA utilization zone (tourism and food security sub-zone) called Sabenibnu, Gallyu, and Warkaket Island (picture 1). Samples were taken at the coastal and marine environment areas. Figure 1 shows the marine debris research location in the villages and the Misool MPA. To make it easier to mention, the sampling location in the sustainable fisheries zone is called a village area because it is located close to the village, while the sampling location in the utilization zone is called MPA because it is relatively further away from the village.

Description of the research location is as follows: Yaganaan Beach located across from Yellu Village, while Yalapale & Dabat Beach located in a village. The waters around Yaganaan & Yalapale are passed by passenger ships from Sorong to Misool. The research location in the MPA is an uninhabited island. The marine area in the MPA is often used as a dive tourism location for resorts, homestays, and cruise ships.

Figure 1. Research locations are in the villages (Yaganaan, Yalapalae, and Dabatan) and conservation areas (Sabenibnu, Gallyu, Warkaket) southern Misool, 2019.

2.2. Procedures

Samples taken in this study were macro-debris (size> 2.5 cm), meso-debris (size 2.5 - 0.5 cm), and micro-debris (size <0.5 cm) on coastal and surface water. The terms and characteristics of the sampling location follow the method by Lippiat et al., 2013. The method of sampling & observing marine debris samples can be seen in Table 1.

2.3. Data analysis

Results of the observations tabulated and analyzed using Microsoft Excel & Power Bi Desktop to produce density and composition based on the debris structure of the collected samples. The meso- & micro-debris composition of the coast and waters were compared using the Sorensen Similarity Index (IS).

Table 1. Sampling Method and observation of marine debris samples in coastal and marine environments in south Misool, 2019

No	Samples	Sampling methods	Observation method
1	Coastal Macrodebris	*Belt transek*, the collected samples (Lippiat et al., 2013)	Direct observation
2	Coastal meso- & microdebris	*The Plot and collected sand beach (Lippiat et al., 2013)*	Sorting based on density and direct observation & microscopic (Vollertsen, 2019; De Witte et al., 2014; Hidalgo-Ruz et al., 2012, Masura et al., 2015; Hiwari et al., 2019)
3	Water surface macrodebris	*Random, direct observation for 1 km, collected samples (Lippiat et al., 2013, Estim & Sudirman 2007)*	Direct observation
4	Meso- & microdebris of water surface	*Random, filtered sea water using plankton net mesh 125µm (Lippiat et al., 2013)*	Filtration and direct observation & microscopic (Vollertsen, 2019; 'Guide to Microplastic Identification', 2006; Masura et al., 2015; Hiwari et al., 2019)

3. Result

The following are collected results:

Density of Macro-debris

The macrodebris density in the village (61 items / 100 m^2) was twice that in the MPA (32 items / 100m^2) (Table 2). Dabatan village has the highest waste density (70.5 items / 100 m^2)

There are different waste densities during low tide and high tide in MPA and Villages. At low tide, the macro-debris density in the village water (5.14 items / 100 m^2) was higher than in the MPA (0.33 items / 100 m^2). However, at high tide, water current and waves lead the waste to the MPA so that the waste density in the MPA (4.60 items / 100 m^2) is higher than in the village (2.53 items / 100 m^2). As at the beach, the highest debris density at low tide was also found in Dabatan village (2.87 items / 100 m^2), while the highest debris density at high tide was found in Warkaket (4.07 items / 100 m^2) (Table 2).

Table 2. Total of coast and marine macrodebris in villages and MPA of South Misool

Areas	Coastal Macrodebris (item/100m^2)	Marine Macrodebris (items/100m^2)	
		Low tide	High Tide
Yaganan	24	1.07	0,13
Yalapale	55	1,20	0,73
Dabatan	70,5	2,87	1,67
Total of Villages	**149,5**	**5,14**	**2,53**
Warakaraket	5	0,33	4,07
Gallyu	22,5	0	0,20
Sabenibnu	68,75	0	0,33
Total of MPA	**96,25**	**0,33**	**4,60**

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Composition of Macro-debris

Plastics are the most abundant type of macro-debris in coastal and marine areas, reaching 91% of the total debris species (Figure 2). Types of waste most commonly found in the waters at high tide and at low tide are pieces of plastic foam, sachets, pieces of plastic film, and plastic bags (Table 3).

Table 3. Types of waste most commonly found in coastal and village marine areas & MPA of South Misool, 2019.

Locations	***Coastal villages***	***Coatsal MPA***	***Low tide village***	***Low tide MPA***	***High tide village***	***MPA high tide***
The most common types	Pieces of plastic foam	Pieces of plastic foam	Sachet	Plastic bags	Pieces of plastic film	Sachet
Density (/100 m^2)	20,083	14,000	0,017	0,003	0,013	0,019

Table 4. Types of macro plastic found in villages and MPA of South Misool, 2019.

No	***Plastic scraps***	***Single-use plastics***	***Fishing equipments***	***Others***
1	Pieces of plastic foam	Bottle of mineral water	Plastic ropes	Balloon
2	Pieces of plastic film	Packaging bottles kemasan	Fishing thread	Cigarette filter
3	Pieces of hard plastic	Medicine bottles		Scoop
4		Electronic wrap		Matches
5		Styrofoam wrap		Children's toy
6		Plastic cups		Plastic tape
7		Shampoo / soap packaging		Jar caps
8		Bottle ring		Sandal
9		Sachet		
10		Straw		
11		Plastic bag		
12		Bottle cap		

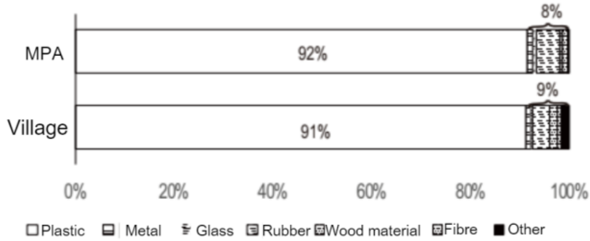


Figure 2. Composition of Macro-debris in village and MPA areas of South Misool.

There are 25 types of macro-plastic found in this study, classified into groups of plastic scraps, single-use plastics, fishing equipment, and others (Table 4). Single-use plastic is the most common type of goods.

Density of Meso- & Microdebris

The meso- and microdebris density in the village was generally greater than that of the MPA (Tables 5 & 6). Table 5 shows the meso-debris density in the waters that has the same tendency as shown in the macrodebris observation. The highest number of mesodebris in the village is found in low tide, while at high tide, the number of mesodebris in the MPA exceeds the village (Table 5). Yalapale is the beach with the most meso- & microdebris compared to other villages.

Table 5. Density of (a) mesodebris and (b) microdebris in coastal & marine areas found in village & MPA of South Misool, 2019.

Areas	***Number of coastal mesodebris(particle /m³)***	***Marine Mesodebris (particle /m³)***	
		Low Tide	**High Tide**
Yaganan	0	0,27	0
Yalapale	2,75	1	0,27
Dabatan	1,50	0,73	0,73
Total of Villages	**4,25**	**2**	**1**
Gallyu	0,75	0,40	1
Warakaraket	0	0,07	0,13
Sabenibnu	0,25	0,07	0,07
Total of MPA	**1**	**0,54**	**1,20**

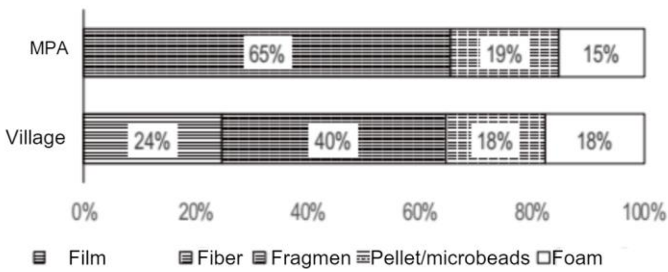
(a)

Areas	***Coastal Microdebris (particle /m³)***	***Marine Microdebris (particle /m³)***	
		Low Tide	**High Tide**
Yaganan	0	0.53	0.07
Yalapale	2.75	0.27	0.13
Dabatan	0.50	1.20	0.40
Total of Villages	3.25	2	0.6
Gallyu	0.25	0.07	0.20
Warakaraket	0.25	0.33	0.07
Sabenibnu	0.25	0	0.07
Total of MPA	0.75	0.40	0.34

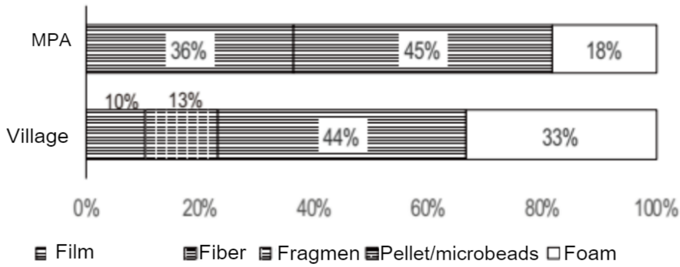
(b)

Composition of Meso- & Micro-debris

All of the meso- and microdebris found were plastic. Based on the structure and source, there are four types of meso- & microdebris found in Misool, namely film, fiber, fragment, and foam. All types of meso- & microdebris found are secondary structures, namely meso- & microdebris which are formed as a result of macro-debris fragmentation. This result is in accordance with the macro-debris composition which is 91% composed of plastic. However, the meso- & microdebris structure varies from location to location. The Sorensen Similarity Index analysis between samples was 0 - 21.43%, indicating that the composition of each sample was very diverse (Table 6). However, the differences in the composition of the meso- & microdebris in the village & MPA are quite clear (Figure 3).



(a) mesodebris



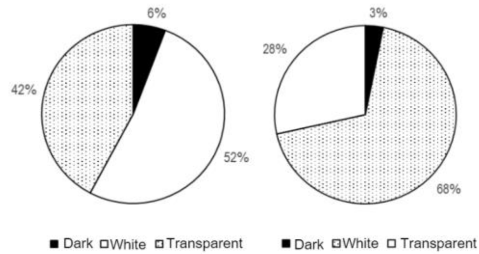
(b) microdebris

Figure 3. Composition of mesodebris & microdebris in Villages & MPA of South Misool, 2019.

The four types of meso- & microdebris were found in the village, whereas in the MPA, not all meso- & microdebris structures were found. There is no dominant type in the village, except for the number of fiber microdebris which reaches 40.38% in the village. Meso-debris in MPA is only composed of fibers, fragments, and foam, while the microdebris are only composed of fibers, fragments, and foam. The amount of fiber mesodebris is quite dominant, reaching 65.38% in KKP. Based on the Sorensen similarity index, there is different composition of meso- & microdebris in all sampling locations of villages & MPAs.

Color of marine debris

Observation results show that color of macro-, meso-, and microdebris has the same tendency, bright color (figure 4).



(a) macrodebris (b) meso- and microdebris

Figure 4. Composition of color (a) macrodebris, (b) meso- and microdebris in South Misool, 2019.

4. Discussion

The factors that give effects on the abundance and composition of marine debris are production of household waste entering ecosystem areas, currents, waves, and UV radiation.

Household waste handling related to the existence of marine debris

Waste made of anthropogenic activity is the main source of *marine debris.* The main contribution for *marine debris* is anthropogenic waste from land activities. Waste produced in land becomes *marine debris* since it intentionally or unintentionally enters the water body such as rivers or beaches. Waste enters the water body intentionally since it is thrown out of place, while it enters unintentionally by leakage of the waste management system in lands (*Indonesia Marine Debris Hotspot*, 2018). The waste becomes *marine debris* and is taken by currents to pollute all areas of waters. Such conditions can be found in MPA (food security and tourism sub-zone) of Misool, as an area with relatively low level of human activities but its coastal and marine areas are polluted by marine debris still in relatively small numbers, though.

Pellet-type debris was not found in all sampling locations. Pellets are primary debris structures, debris that are created in micro-forms, generally ellipses, which are usually used in beauty products (microbead scrubs), industry (refiners), and materials for producing plastic objects (Anderson et al. 2016). Pellets were not found in Misool because there were no industrial activities and the use of other pellet products in Misool.

The composition of waste found in coastal areas and waters is similar to anthropogenic waste, for example single-use plastics, sandals, fishing line, and Styrofoam. This is evidence that human-generated waste causes marine debris. Currently, waves and wind are the main factors causing the distribution of marine debris. The debris form found at the site is only secondary debris, which is formed by the fragmentation process.

Current, waves, and wind as the factors causing for distribution of *marine debris*

The waste entering the marine areas is then taken by the current so it can be distributed to other marine areas. This is also observed in some studies taken in some open marine areas. Current, waste and wind are also determined as the factors causing distribution of macro and micro *marine debris*.

The dominated debris composition found out is plastic. Different characteristics of plastics between can and glass cause the materials to be easily distributed. This also gives effects on composition and distribution of all meso- and micro-debris composed by plastic. Various sizes and forms can be caused by the plastic fragmentation process. Similar results can also be seen in a study by Tahir et al. (2018), showing current as the main factor causing distribution of debris in marine areas.

Such conditions illustrate the effects of current on distribution of debris. Both marine areas are directly opposite the open sea so that the currents carry debris into the waters. Sampling carried out at the beginning of the southern season also gives effects on debris density taken into the Warkaket waters, which are located in the south and directly adjacent to the high seas.

Macroplastic fragmentation into meso- and microplastic

Macroplastic fragmentation into small particles is influenced by radiation of UV, atmospheric chemical reactions, and other physical factors such as animal bites (Thushari et al. 2017). The foam particles are assumed to have originated from fishermen and fish collector activities who generally use Styrofoam boxes to store fishing rods. Fiber particles are formed from degradation of net, fishing line, rope, and clothing materials. The fragments are composed of hard plastic, generally *polyethylene* (PET) (Thushari et al., 2017) which is a plastic with a fairly heavy density, but it is possible to have *high density polyethylene* (HDPE), *polypropylene* (PP), and other types. Plastic film is a fragment of single-use plastic waste such as plastic bags and sachets. This shows that pollution from single-use plastics occurs in the marine environment.

Reduced marine debris by education to the community

Household waste management will have effects on the existence of *marine debris.* This can be seen from the data on distribution and composition of macro-, meso- and microdebris in Yalapale Village (Table 2 and 5). The number of macrodebris in Yalapale is in the second rank based on the research location, but, for the meso and micro debris, it has the lowest level. There are two assumptions for the cause of this issue.

First, the types of meso- & microplastic found in Yalapale could be primary debris, namely debris produced in micro form for industrial activities. This primary debris is produced in the form of pellets. However, this assumption is wrong, by referring to no pellets found in the meso- & microdebris composition at Yalapale. Then this conjecture can be eliminated.

The second assumption is high fragmentation of macro-debris into meso- and micro-debris that washed ashore. However, if this is true, it should be that Dabat village with the highest number of macrodebrises should have the highest meso- & microdebrises too. Human intervention is assumed to be another factor that gives effects on this condition. Waste bank unit that has just been built in this village (not yet in Dabat) is the cause of the low number of macrodebris in Yalapale village because it is collected by residents to be sold to a waste bank. Meso- & microdebrises can still be found in the environment because they are not observed and cannot be collected easily. These results give hope that an approach to the community through education programs and waste banks can reduce the amount of waste thrown away carelessly.

5. Conclusion

This study concludes that marine debris is found on the coastal and marine areas of the Misool MPA. There are various sizes of marine debris found ranging from macro-, meso-, and micro-debris. The most size found on the coastal area around the village, village waters at low tide, and MPA waters at high tide is the macrodebris. Currents and tides also serve as the main factors leading to macrodebric movements. Macro-chemical compositions were plastic, metal, glass, rubber, and others. Plastics are the dominant type (91% of the total macro-debris) composing the macroplastics. Plastic scraps, single-use plastics, and fishing rods (nylon and plastic-based nets) are also identified as the macro-debris groups.

Meso- & microdebrises are found mostly in coastal and village marine areas during high tide and low tide. 100% of the meso- & microdebris found is plastic. Meso- and micro-debris structures were fiber, foam, fragmentts, and film. All meso- and micro-debris were secondary meso- and micro-debris which were formed due to macro-debris fragmenttation. The presence of marine plastics which dominantly compiles marine debris gives effects on environmental and industrial sectors. Educating the community can reduce marine macro-debris stranded on the beach.

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References

Andrades, R. et al. 2018. Marine debris in Trindade Island, a remote island of the South Atlantic. Marine Pollution Bulletin: 180–184.

Barnes, D. K. A. et al. 2009. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526): 1985–1998.

Beaumont, N. J. et al. 2019. Global ecological, social and economic impacts of marine plastic. Marine Pollution Bulletin 142: 189–195.

Bergmann, M., Gutow, L. and Klages, M. 2015. Marine Anthropogenic Litter. Springer Open.

Blettler, M. C. M. et al. 2017. Plastic pollution in freshwater ecosystems: macro-, meso-, and microplastic debris in a floodplain lake. Environmental Monitoring and Assessment. Environmental Monitoring and Assessment 198(11): 1-13

Boerger, C. M. et al. 2010. Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. Marine Pollution Bulletin 60(12): 2275–2278.

Cole, M. et al. 2011. Microplastics as contaminants in the marine environment: A review’, Marine Pollution Bulletin 62(12): 2588–2597.

De Witte, B., Devriese, L., Bekaert, K., Hoffman, S., Vandermeersch, G., Cooreman, K., Robbens, K. 2014. Quality assessment of the blue mussel (*Mytilus edulis*): Comparison between commercial and wild types. Marine Pollution Bulletin 85(1):146-155.

Duhec, A. V. et al. 2015. Composition and potential origin of marine debris stranded in the Western Indian Ocean on remote Alphonse Island, Seychelles. Marine Pollution Bulletin 96(1–2): 76–86.

Estim, A. and Sudirman, R. 2017. Types and abundance of macro-and micro-marine debris at Sebatik Island, Tawau, Sabah. Borneo Journal of Marine Science and Aquaculture 01: 1–57.

Hidalgo-Ruz, V. et al. 2012. Microplastic in the Marine Environment: A review of the methods used for identification and quantification. Pediatriya - Zhurnal im G.N. Speranskogo 46(9): 69–70.

Hiwari, H. et al. 2019. Kondisi sampah mikroplastik di permukaan air laut sekitar Kupang dan Rote, Provinsi Nusa Tenggara Timur. Jurnal PROS SEM NAS MASY BIODIV INDON 5: 165–171.

Indonesia Marine Debris Hotspot. 2018. World Bank Group, Kementerian Koordinator Bidang Kemaritiman. Embassy of Denmark.

Lippiatt, S., Opfer, S. and Arthur, C. 2013. Marine debris Monitoring and Assessment. NOAA Technical Memorandum (NOS-OR&R-46).

Lusher, A. L. et al. 2015. Microplastic and macroplastic ingestion by a deep diving, oceanic cetacean: The True’s beaked whale Mesoplodon mirus. Environmental Pollution 199: 185–191.

Lusher, A. L., McHugh, M. and Thompson, R. C. 2013. Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. Marine Pollution Bulletin 67(1–2): 94–99.

Masura, J. et al. 2015. Laboratory methods for the analysis of microplastics in themarine environment: Recommendations for quantifying synthetic particles in waters and sediments. NOAA Technical Memorandum NOS-OR&R-48.

Opfer, S., Arthur, C. and Lippiatt, S. 2012. NOAA Marine debris Shoreline Survey Field Guide. NOAA Marine debris Program.

Pham, C. K. et al. 2017. Plastic ingestion in oceanic-stage loggerhead sea turtles (Caretta caretta) off the North Atlantic subtropical gyre. Marine Pollution Bulletin 121(1–2): 222– 229.

Reichert, J. et al. 2018. Responses of reef building corals to microplastic exposure. Environmental Pollution 237: 955–960.

Song, Y. K. et al. 2015. A comparison of microscopic and spectroscopic identification methods for analysis of microplastics in environmental samples. Marine Pollution Bulletin 93(1–2): 202–209.

Syakti, A. D. et al. 2017. Beach macro-litter monitoring and floating microplastic in a coastal area of Indonesia’, Marine Pollution Bulletin, 122(1–2), pp. 217–225.

Tahir, A. et al. 2015. Short term observation on marine debris at coastal areas of Takalar District and Makassar City, South Sulawesi – Indonesia. Jurnal Ilmu Kelautan SPERMONDE 4(2): 1–6.

Vollertsen, J. 2019. Overview of methods and challenges for microplastic analysis. http://www.svensktvatten.se/globalassets/utbildning/konferenser-och- seminarier/microplastics/03_vollertsen_microplastic-intro.pdf.

Wright, S. L., Thompson, R. C. and Galloway, T. S. 2013. The physical impacts of microplastics on marine organisms: A review', Environmental Pollution 178: 483–492.

Zhao, S. et al. 2014. Suspended microplastics in the surface water of the Yangtze Estuary System, China: First observations on occurrence, distribution. Marine Pollution Bulletin 86(1–2): 562–568.

Zhou, C. et al. 2015. Marine debris surveys on four beaches in Rizhao City of China. Global Journal of Environmental Science and Management 1(4): 305–314.

Andrady, A. L. 2011. Microplastics in the marine environment. Marine Pollution Bulletin 62(8): 1596–1605.

Beaumont, N. J., Aanesen, M., Austen, M. C., Börger, T., Clark, J. R., Cole, M., Hooper, T., Lindeque, P. K., Pascoe, C., & Wyles, K. J. 2019. Global ecological, social and economic impacts of marine plastic. Marine Pollution Bulletin 142: 189–195.

Gall, S. C., & Thompson, R. C. 2015. The impact of debris on marine life. Marine Pollution Bulletin 92(1–2): 170–179.

UNEP. (2014). Microplastics: trouble in the food chain. 32–43.