197-Article_Text-725-1-10-20230614.pdf

by Eni Kamal

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Science and Environmental Journals for Postgraduate
Vol. 5 No. 2 (pp. 145-152) June 2023
p_ISSN 2655-5085
e_ISSN 2655-5239

Review of Microplastic Pollution in Indonesian Waters

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Received: 06 Mar. 2023, Revised: 23 Apr. 2022, Accepted: 01 Jun. 2022

ABSTRACT

Mismanaged plastic wastes still become the main environmental problem in many countries. It is also believed as the root of many environmental problems today faced by both advanced and developed countries, like Indonesia. Microplastics that polluted the aquatic environment of Indonesia today mainly come from mismanaged plastic wastes (secondary), but both the primary and secondary microplastics exist in Indonesian water. This paper reviews microplastic pollution in Indonesian water and focused on two main topics, namely the characteristics of microplastics in Indonesian waters and their sources and the effects of the presence of microplastics on aquatic organisms. This article was compiled using secondary data consisting of various data and papers, and materials obtained from various sources of relevant and reliable official publications that are closely related to the microplastic pollution in Indonesian waters. These findings were then analyzed in an explanatory descriptive manner to provide an overview of characteristics and the sources of microplastics in Indonesian waters and how microplastics affect aquatic ecosystems. It is hoped that this will provide an opportunity to address this issue more effectively.

KeyWords: Plastic Waste, Microplastic, Pollution, Aquatic Organisms, Human.

INTRODUCTION

Plastic is one of the most widely used materials by humans with very wide applications in daily and commercial life. Plastic production has increased significantly since the 1950s (Tankovic *et al*., 2015). Total production continues to grow, from 204 million tons in 2002 and is expected to be 359 million tons in 2018 (Oliver, 2015). However, humans are often not aware of the long-term impact generated by the use of plastic. Plastic waste produced by humans is ultimately discharged into the environment. The more plastic is used, the more plastic waste is wasted into the environment. Galgani (2015) adds, plastic waste that is dumped into the environment eventually enters the waters, especially the sea. Plastic is the main component of waste found in the sea, reaching almost 95% of the total waste accumulated on the shoreline, surface, and seabed.

Plastic waste has spread widely throughout the world's oceans. In both microplastic and macroplastic forms, plastic waste is found in almost all marine habitats, including in remote locations such as the Arctic, South Ocean, and very deep waters (Barnes *et al*., 2010). The process of decomposing plastics generally takes place very slowly and takes up to hundreds of years for plastic to be degraded into microplastics and nano plastics through various physical, chemical, and biological processes (Galgani, 2015).

Microplastics are plastic particles with a diameter of less than 5 mm (Andrady, 2011). Although there is no definite limit for the size of microplastic particles, most studies take particle objects with a minimum size of 300 μm. Microplastics can be classified into two size categories, namely large (1-5 mm) and small (<1 mm) (Storck, 2015). Microplastics can be found in various characteristic groups including variations in size, shape, color, composition, density, and other properties.

The size of plastic waste affects the impact of its contamination on marine life. Large plastic waste, such as fishing lines and nets, often traps animals (Carr, 1987). On the other hand, plastic waste of smaller sizes such as bottle caps, matches, and plastic pellets can be ingested by living things in the waters and cause intestinal obstruction and the risk of exposure to toxic chemicals (Fry *et al*., 1987). In a different context, microplastics can be ingested by the smallest organisms in the marine environment and cause more serious consequences, which are still not fully understood (Tankovic *et al*., 2015).

Humans are starting to realize the bad impact caused by plastic waste pollution in water areas. Many research efforts have been made to understand the extent to which pollution occurs and the impacts it causes. Research that is currently developing is not only focused on marine areas but also freshwater areas because they can cause harmful impacts on ecosystems and also for humans (Eerkes-Medrano *et al*., 2015).

This paper reviews microplastic pollution and focused on two main topics. First, a literature review will be carried out regarding the characteristics of microplastics in Indonesian waters, and then will explain the sources and effects of the presence of microplastics on aquatic organisms. By utilizing understanding from marine literature and existing research, it is expected to deepen understanding of microplastic contamination in waters. It is hoped that this will provide an opportunity to address this issue more effectively.

METHODS

This article was compiled using secondary data consisting of various data and papers, materials obtained from various sources of relevant and reliable official publications that are closely related to the microplastic pollution in Indonesian waters, such as journals, articles, and various related opinions that have been published. These findings were then analyzed in an explanatory descriptive manner to provide an overview of characteristics and the sources of microplastics in Indonesian waters and how microplastics affect aquatic ecosystems.

FINDINGS

3.1 Characteristics of Microplastics in Indonesian Waters

Microplastics have been found in various aquatic environments such as oceans, coasts, beaches, rivers, and lakes. The widespread use of plastic products which eventually form microplastics shows that Indonesian waters have a large potential for microplastic contamination, as shown by the studies described in Table 1. Estimating the level of microplastic contamination in a certain water area is carried out by taking water samples from the waters and then analyzed.

Table 1. Abundance of microplastics in different locations in Indonesian waters

Location	Source	Abundance	Reference
Surabaya River	River Waters	1,33 particles/L	Wijaya *et al*., 2019
Ciwalengke River	River Waters	Water: 5.85-3.28 particles/L Sediment: 3.03-1.59 particles/L	Alam *et al*., 2019

Location	Source	Abundance	Reference
Kalimas, Surabaya	River Waters	0.049 - 0.095 items/m^3	Fitriyah *et al*., 2022
Banyuurip River, Gresik	River Waters	7.78 x 10^5 particles/L	Ayuningtyas, 2019
DKI Jakarta River Estuary	Estuarine Waters	205 particles/L	Purba, 2019
Muara Gembong	Estuarine Waters	86.13 particles/L	Sembiring, 2020
Mangrove Forest, Jambi	Estuarine Waters	292 particles/L	Fitri & Patria, 2019
Muara Bombong, Batangas	Estuarine Waters	10.67 particles/L	Espiritu *et al*., 2019
Gili Labak Island, Sumenep Regency	Marine Waters	189,000 particles/km^2	Lolodo & Nugraha, 2020
Kupang and Rote, NTT	Marine Waters	81.5 particles/L	Hiwari *et al*., 2019
Tengah Island, Karimun Java	Waters Sea	142.44 particles/m^3	Salsabila *et al*., 2023
Benoa Bay, Province of Bali	Gulf Waters	430-580 particles/L	Hafidh *et al*., 2018
Pramuka Island, Jakarta Bay	Gulf Waters	185 particles/L	Priscilla *et al*., 2019
Bali strait	Straits waters	[illegible].48 x 103 particles/L	Yona *et al*., 2019
Kamal Estuary	Estuarine Waters	Water: 103.8 ± 20.7 items/L Sediment: 111680 ± 13204 items/kg	Priscilla & Patria, 2019
Marunda	Waters bay	Water: 90.7 ± 17.4 items/L Sediment: 82480 ± 11226 items/kg	Priscilla & Patria, 2019
Pariaman City Coast	Waters Sea	178.89 – 235.56 particles/kg	Sianturi *et al*., 2021
Flow and estuary of Musi River	River Waters	1,782 particles / gram	Ahmad *et al*., 2018
Downstream Part of Musi River	River Waters	Station 1 Gandus: 0.73 particles/gr; Station 2 Ampera 1.38 particles/gr; Station 3 Pusri 1.07 particles/gr; Station 4 Upang 0.82 particles/gr; Station 5 Muara Breech 1.69 particles/gr; and Tanjung Carat 6 stations 0.80 particles /gr	Renaldo *et al*., 2022
Air Manis Beach, Padang City	water sea	Water 1,667-5,000 particles/L Sediment 16,8[illegible]86,684 particles/kg	Fadel & Jamika, 2021
Water village harbor	River waters	Stations river, an average of 30,250 particles /l ± 1[illegible]5 Stations pond, an average of 18,917 particles /l ± 11,453	Sasmito *et al*., 2018

The forms of microplastic that are commonly found in water areas are in the form of fibers, fragments, and filaments (Fitriyah *et al*., 2022), fibers and pellets, fragments, filaments, films, foams, and granules (Purba *et al*., 2019). The color of the microplastic varies from transparent, blue, black, yellow, and red filaments (Fitriyah *et al*., 2022). Microplastic particles found in surface waters range in size from 0.355 mm – 0.999 mm (Purba *et al*., 2019) and range from 1 mm to 5 mm (Rahmad *et al*., 2019). Fragment form is the dominant form of microplastic in surface waters. This is caused by the fragmentation of plastic bottles, single-use plastic bags, and polyethylene (PE) and polypropylene (PP) plastics which have a relatively light density, so they tend to float in the waters. Microplastic fragments accumulate due to gravity and their density is higher than the density of water (Eriksen *et al*., 2013). In addition, the distribution and spread of microplastics in the aquatic environment can originate from waste management systems that are not managed properly (Lestari & Trihadiningrum, 2019). Fiber microplastics generally come from domestic waste from washing clothes (Eriksen *et al*., 2013). Microplastic pellets may originate from microbeads in beauty products such as facial cleansers, cosmetics, and personal care (toiletries) (Mani *et al*., 2015).

In terms of polymer types, the type of microplastic that is often found in surface waters is polyethylene (PE) which comes from plastic beverage packaging products (Ebere *et al*., 2019). Meanwhile, according to Salsabila *et al* (2023), the types of microplastic polymers that are commonly found are Nitrile, HDPE, LDPE, PVA, and PP. The results of a study conducted by Rahmad *et al* (2019) found that the microplastic content in the surface area is more than at a certain depth below the water surface. The abundance of microplastics at a depth range of 1 meter is 116 particles while on the surface there are 205 microplastic particles (Rahmad *et al.,* 2019). This is similar to the statement of Mato *et al*. (2001) which states that plastic has buoyancy properties because of the mass it has. When viewed from the tidal conditions, high tide conditions have fewer microplastics compared to low tide conditions with a ratio of 150 microplastic particles during high tide conditions, while low tide conditions have as many as 171 microplastic particles (Rahmad *et al.,* 2019). These results can be explained based on current data in the study area. During high tide conditions, the currents in the estuary enter the estuary. Meanwhile, when the waters recede, the currents in the estuary head outward towards the estuary or the ocean.

3.2 Sources and effects of the existence of microplastics on aquatic organisms

Two types of microplastics contaminate world waters, namely primary and secondary microplastics. Microplastics are classified as primary when originally manufactured to a small size and then released directly into the environment and secondary if it comes from the decomposition of larger plastic items (Boucher & Friot, 2017; Alam *et al*. 2019; Sutanhaji, 2021).

Primary microplastics could be originated from the manufacture of beauty products or toiletries, e.g., scrubbers in shower gels (Boucher & Friot, 2017; Alam *et al*, 2019). Meanwhile, secondary microplastics could happen through photodegradation and other weathering processes of mismanaged waste such as discarded plastic bags or from unintentional losses such as fishing nets (Boucher & Friot, 2017; Alam *et al*, 2019; Basri *et al*, 2021). Around 4,8 to 12,7 million tons of secondary plastic enter the ocean annually to which Indonesia has contributed almost 1,29 tons/year. Although mismanaged plastic waste is still the main global source of marine plastic pollution (Boucher & Friot, 2017; Sutanhaji *et al*, 2019), in some countries, more plastic may be released from daily activities such as driving and washing (primary microplastics) than from the mismanagement of waste (Boucher & Friot, 2017). Yes, countries in the world must prioritize the reduction of mismanaged plastic waste especially in today's climate change condition and within the frameworks of SDGs. But for many regions and sectors, there also should be solutions to reduce the release of primary microplastic into the environment. Because both microplastic types affected not only aquatic organisms but also humans. They are ingested by an array of marine habitats like corals, plankton, fish, seabirds, and marine mammals and are transferred along the food chain (Chatterjee & Sharma, 2019). Microplastics can harm the reproductive health of marine life because of their toxic effect. They could also reduce food intake, delaying growth, causing oxidative damage, and abnormal behavior of aquatic organisms. There are so many problems that can occur in each marine organism due to ingesting microplastics as kindly summarized by Bajt (2021) as follows:

Table 2. Microplastics' impact on marine organisms

Marine organisms	Impacts	References
Microalgae	Reduced the photosynthetic activity and algae growth.	Bhattacharya *et al,* (2010); Arun (2019)
Copepods	Reduced hatching success, survival, reproduction rate and feeding capacity, and total lipid content.	Cole *et al* (2014); Sonaipandian (2019)
Artemia	Affected survival rate, cyst production, and nauplii hatching succession.	Aravindhsamy (2019)
Fishes	Gut blockages and transfer of chemicals in fishes, decreased feeding rate and Gut blockages, Caused Inflammation, oxidative stress, and disrupted energy metabolism.	Ory *et al*, (2018); Cheung *et al*, 2018, Choy and Drazen, 2013

Marine organisms	Impacts	References
Crustaceans	Reduced fecundity, offspring developmental delay, food uptake, enzyme activity impairment, and behavioural alteration.	Cole *et al*, (2015); Devriese *et al,* (2015)
Benthos	Benthic suspension and deposit feeders were found to ingest the sinking and sedimentary microplastics.	Wright *et al*, 2013, Egbeocha *et al*, 2018
Molluscs	Reduced filtering/feeding efficiency in mussels, caused feeding modifications and reproductive disruption in oysters, Contaminated microplastics molluscan species may be a source of human microplastic intake.	Sussarellu *et al*, 2016, Baird, 2016, Naji *et al*, 2019
Coral reefs	Reduced the calcification process, Reduced the skeletal growth and coral skeleton mineralization rates.	Reichert *et al*, 2018, Chapron *et al*, 2018.
Marine plants	The dominant type of MPs observed in some mangrove sediments were polyethylene, polypropylene and polystyrene.	Barasarathi *et al*, 2014; Li *et al*, 2018.

Humans are both the culprit and victims of the ecotoxicological impact of microplastics as it relates to the consumption of aquatic food products contaminated with microplastics (Iheanacho, 2023). All the solution for reducing the impact of microplastic on aquatic organisms is likely depend on how human choose to plan and act in prevent the producing of plastic waste and release of plastic waste into the environment especially body of water.

CONCLUSIONS

Microplastic is commonly found in Indonesian water areas in many sizes (from 0.355 to 5 mm), forms (such as fibers, fragments, filaments, pellets, films, foams, and granules), and colors (from transparent, blue, black, yellow and red filaments). The main source of microplastic waste in the ocean globally came from secondary microplastic that derived from mismanaged waste. However primary microplastic is still present in the ocean as well therefore both microplastic sources need to be resolved. They have directly impacted the aquatic organisms negatively and end up effected the human. So, in the case of microplastic pollution in the environment, human plays as the culprit and the victim. Therefore, it's humans that first need to take action to reduce and prevent the pollution of microplastic.

ACKNOWLEDGMENTS

The authors express gratitude to Allah SWT who has bestowed His grace and guidance. The author also thanks the lecturers of Aquatic Ecology Courses, Doctoral Program of Environmental Science - Postgraduate School of UNP, who always give encouragement and motivation to the authors.

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