Songklanakarin J. Sci. Technol.
44 (3), 609-618, May - Jun. 2022

http://www.sjst.psu.ac.th

Review Article

A review on microplastic ingestion in marine invertebrates from Southeast Asia

Haryati Hasbudin, Mohd Nasarudin Harith*, and Farah Akmal Idrus

Faculty of Resource Science and Technology, Universiti Malaysia Sarawak,
Kota Samarahan, Sarawak, 94300 Malaysia

Received: 11 August 2021; Revised: 12 November 2021; Accepted: 19 November 2021

Abstract

The microplastic ingestion of marine invertebrates around ASEAN countries namely, Indonesia, Malaysia, Philippines, Thailand, and Vietnam were reviewed. The review involves locations, species, concentration of microplastics, as well as dominant colors and types of microplastics. The most studied species was *Perna viridis*. The highest concentration of microplastic was found in *Laevistrombus turturella* with 628 ±191.93 particles/individual. Black was the most common dominant color of microplastics and fiber was the most common type of microplastics found in the marine invertebrates. Two lab-based studies of microplastic ingestion in *Acropora formosa* and *Perna viridis* had shown detrimental effects of microplastics. The challenges of microplastic ingestion study around ASEAN was the possibility of microplastic entering seafood food security in both wild and farmed populations, as well as the probable collapse of the coral reef ecosystem.

Keywords: microplastics, invertebrates, ASEAN, Southeast Asia

1. Introduction

The term microplastics refers to "*any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 μm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water*" (Frias & Nash, 2018). The ingestion of microplastics in marine invertebrates has been recorded worldwide from the coastal beaches (Horn, Miller, Anderson, & Steele, 2019) to the deepest point of Earth (Jamieson *et al*., 2019). Marine invertebrates are potentially suitable as an environmental bioindicator for microplastics (Ding *et al*., 2021; Macali & Bergami, 2020). However, the use of marine invertebrates as bioindicators of microplastics is still at a preliminary stage due to other critical aspects include the standardization of sampling protocols, analytical detection methods and metrics to evaluate the effects of ingested plastics in marine species (Bonanno & Orlando-Bonaca, 2018). Nevertheless, the studies of microplastic ingestion in marine invertebrates conducted in Southeast Asia is still not extensively conducted compared to the other regions despite the Southeast Asia region being one of key contributors to the number of marine plastics in the environment globally (Lyons, Linting, & Neo, 2019). This is due to the Southeast Asia region being predominantly developing countries that still lack waste management strategies (Richie & Roser, 2018) and the issue of microplastic is still recent and at an early stage in the scientific community of Southeast Asia (Lyons, Neo, Lim, Tay, & Dang, 2020). The objectives of this study were focused to investigate the location and species of studies around Southeast Asia namely Indonesia, Malaysia, Philippines, Thailand, and Vietnam, the concentration of microplastics in marine invertebrates and the characterization of microplastics through the dominant colors and types. Then, the lab-based studies of microplastic ingestion in marine invertebrates are also being reviewed. Lastly, the microplastic ingestion in marine invertebrates' challenges and limitations around Southeast Asia would be explained. Study period was conducted for eight months.

2. Location of Interest

The majority of microplastic ingestion in marine invertebrates' studies were conducted at Java Island since it is the location to most Indonesia's educational institutions

---

*Corresponding author
Email address: hmnasarudin@unimas.my

(Figure 1). Six theses from the Universitas Katolik Seogijapranata were gathered online with the sampling locations focusing on Semarang, northern Central Java that facing Java Sea, as seen on the map thus highlighting the abundance of location studies there. Four of the six theses collected their marine invertebrates' samples from Semarang's traditional markets (Adidharma, 2019; Angganararas, 2019; Nurulchusna, 2018; Sudianto, 2019). The fishermen and sellers at the traditional markets obtained their seafood from the north coast of central Java along the Java Sea (Angganararas, 2019). Meanwhile, the studies conducted at Celebes Island, Indonesia is limited to the coastal area South Celebes. El *et al*. (2020) has collected marine invertebrates' samples from traditional market at South Celebes meanwhile Tahir *et al*. (2019) and Sari (2018) chose Spermonde Archipelago islands at South Sulawesi due to its proximity to the island's coast (Tahir *et al*., 2019). Only two studies have been performed in Sumatera, with both study sites being Wisata Mangrove Pangkal Babu, a mangrove forest (Fitri & Patria, 2019a, 2019b).

Meanwhile in the Philippines, Argamino and Janairo (2016) obtained cultured *P. viridis* from Sineguelasan Seafood Terminal, Bacoor Bay, whereas Espiritu *et al*. (2019) obtained samples from the downstream of the Bombong estuary, Tayabas Bay. For Thailand, both Tharamon, Praisankul, and Leadprathon (2016) and Thushari, Senevirathna, Yakupitiyage, and Chavanich (2017) sampling locations are from the Gulf of Thailand. Meanwhile, Pradit *et al*. (2021) bought the samples from local fish market near Songkhla Lake. Nam, Tuan, Thuy, Quynh, and Amiard (2019) obtained wild *P. viridis* from Tinh Gia, Vietnam where it is the most northern location of all samplings across Southeast Asia.

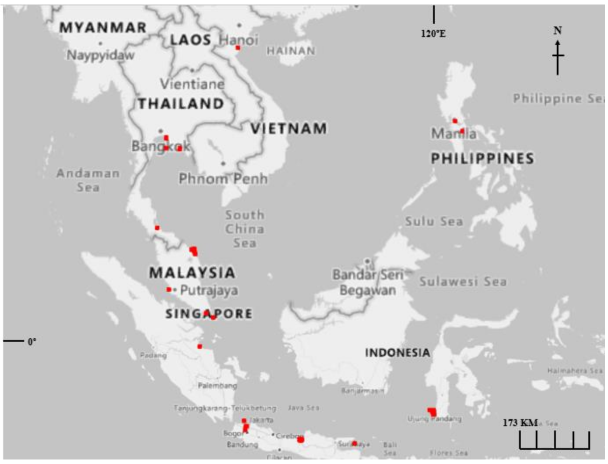

Figure 1. Red dots indicate the location studies of microplastic ingestion in marine invertebrates across Southeast Asia

3. Concentration of Microplastics in Marine Invertebrates

According to Table 1, most of the literature focuses on gastropod and bivalve animals. *P. viridis* is the most common species that has been studied in Southeast Asia. The widely distributed factor, successful aquaculture species, and the habitat location at intertidal and sublittoral areas has made it widely available for these studies (Centre for Agriculture and Bioscience International, 2019). The discovery of microplastic in this species should act as a signal to the community that microplastic might pose a significant threat to Southeast Asia's food security. Comparison of microplastic concentration among the studies are difficult due to different form of data presented for the concentration of microplastics. Some studies provide mean concentration of microplastics from each sampling location (Adidharma, 2019; Angganararas, 2019; Ibrahim, Azmi, Shukor, Anuar, & Abdullah, 2016; Khoironi *et al*., 2018; Petala & Tsabita, 2018; Tharamon *et al*., 2016; Thushari *et al*., 2017; Sudianto, 2019; Wirasandjaja, 2019) meanwhile Zaki, Zaid, Zainuddin, and Aris (2021) only provided range of microplastic concentrations.

The highest concentration of microplastics (particles/individual) in marine invertebrates collected by *Laevistrombus turturella* with 628 particles/individual from shore area that has significant tourism activities (Hamra & Patria, 2019). *L. turturella* is an edible but not cultured gastropod species that preferred to live on minimally covered seagrass beds (Supratman & Tati, 2018) due to their foraging behavior as deposit feeder (Nezaputri, Kurniawan, Suryanti, Muzahar, & Susiana, 2021). Hamra and Patria (2019) also collected the sediments from each station and discovered the same station has the highest concentration of microplastics in sediments (1136 ± 154.75 particles/kg). Thus, there is a possible connection between the microplastics in sediments and microplastic ingested by *L. turturella*. The ingestion of sand sediment will lead to ingestion of microplastics that aggregate within the sand sediment because sand is the second most dominating diet in stomach content analysis (Supratman & Tati, 2018). Hamra and Patria (2019) also concluded the role as deposit feeder made the species more susceptible to ingest microplastics.

Species involved in this research are dominated by bivalves that are a filter feeder animal. The vulnerability of filter-feeding animals to microplastics due to bivalves effectively ingest microplastics in water columns and their coastal habitats makes them reside closer to the microplastics sources (Setälä, Norkko, & Lehtiniemi, 2016). However, all bivalve species except *A. granosa* and *P. viridis* obtained less than 50 particles/individual. Egbeocha, Malek, Emenike, and Milow (2018) suggested bivalves' preferential feeding mechanisms allows them to reject non-food particles as pseudofeces. Pseudofeces are mucus-bound clump of particles that have been filtered but then rejected from the mantle cavity of the bivalve, thus preventing microplastics from being digested. Bivalves can successfully eliminate more than 40% of microplastic particles as pseudofeces or feces (Zhao, Ward, Danley, & Mincer, 2018), indicating bivalves would be poor bio indicators of microplastic pollution in the environment (Ward *et al*., 2019). Moreover, bivalves' samples that were collected from traditional markets may have eradicated the microplastics through pseudofeces mechanism during the transportation period to the traditional markets.

According to Table 1, the highest amount of mean concentration in microplastic (particles/gram) is from *Scapharca cornea* with 557.98 particles/gram (Ibrahim *et al*., 2016). The location of sampling resulted to higher concentration to microplastics because it has less water movement, allowing the microplastics particles to reside for

Table 1. Microplastic concentrations in species studied across Southeast Asia

Class	Species	Number of samples (n)	Chemical for extraction	Identification	Concentration (mean ± SD)		Country & Sampling area type	References
					Particles/ individual	Particles/ gram		
Bivalvia	*Anadara granosa*	60	KOH	FTIR	5.1 ± 3.5 (Batch 1) 5.3 ± 3.13 (Batch 2)	-	Indonesia (coastal)	Ichlasia (2017)
		15	HNO_3	Observation	434 ± 97.05	9.8 ± 2.26	Indonesia (mangrove)	Fitri and Patria (2019a)
	Crassostrea iredalei	-	HNO_3	Observation	40 total particles	-	Philippines (estuary)	Espiritu *et al.* (2019)
	Donax sp.	12	H_2O_2	Observation	3.13±2.75 (Chaolao beach) 2.98±3.12 (Kungwiman beach)	-	Thailand (coastal)	Tharamon *et al.* (2016)
	Mactra sp.	35	KOH	FTIR	2.11 ± 0.29	-	Indonesia (island)	Mawaddha *et al.* (2020)
	Malleus sp.	3	KOH	Observation	0.125	-	Indonesia (islands)	Sari (2018)
	Meretrix meretrix	50	H_2O_2	Observation	-	12.9	Indonesia (coastal)	Hardianti (2019)
		20		FTIR	6.7	-	Indonesia (coastal)	El *et al.* (2020)
	Paphia sp.	6	H_2O_2	Observation	11.31±2.03 (Chaolao beach)	-	Thailand (coastal)	Tharamon *et al.* (2016)
	Perna viridis	30	H_2O_2	-	-	5 particles/ 0.25 gram (High salinity location) 2 particles/ 0.25 gram (Low salinity location) 1 particle/ 0/25 gram (Brackish location)	Indonesia (coastal)	Khoironi *et al.* (2018)
		90	KOH	Observation	11.12 ± 2.98	-	Indonesia (traditional market)	Nurulchusna (2018)
		50	KOH	-	-	4	Indonesia (coastal)	Hardianti (2019)
				-	1.95 ± 1.14	0.58 ± 0.25	Malaysia [strait (aquaculture site)]	Maha (2019)
		5	KOH	µFTIR	2.60 ± 1.14	0.29 ± 0.14	Vietnam (coastal)	Nam *et al.* (2019)
		50	KOH	-	34.16 ± 10.85 (Location A) 29.92 ± 12.14 (Location B) 115.50 ± 51.42 (Location C) 114.49 ± 39.17 (Location D) 59.43 ± 15.94 (Location E)	16.25 ± 23.47 (Location A) 10.09 ± 4.14 (Location B) 54.70 ± 20.29 (Location C) 54.66 ± 15.58 (Location D) 30.33 ± 7.80 (Location E)	Indonesia (coastal)	Wirasandjaja (2019)

Table 1. Continued.

Class	Species	Number of samples (n)	Chemical for extraction	Identification	Concentration (mean ± SD)		Country & Sampling area type	References
					Particles/ individual	Particles/ gram		
Bivalvia	*Perna viridis*	99	KOH	-	-	0.13 ± 0.08 (Shell range 4-5.9 cm) 0.07 ± 0.03 (Shell range 6-7.9 cm) 0.04 ± 0.02 (Shell range 8- 10cm)	Indonesia (island)	Fachruddin *et al.* (2020)
		35	KOH	FTIR	14.62 ± 1.46	-	Indonesia (island)	Mawaddha *et al.* (2020)
	Pinctada sp.	5	KOH	Observation	0.08	-	Indonesia (islands)	Sari (2018)
		12	KOH	Observation	0.3	-	Indonesia (islands)	Tahir *et al.* (2019)
	Pinna muricata	4	KOH	Observation	0.25	-	Indonesia (islands)	Sari (2018)
	Pinna sp.	6	KOH	Observation	0.5	-	Indonesia (islands)	Tahir *et al.* (2019)
	Saccostrea forskalii	150	HNO_3	Raman	-	0.57 ± 0.22 (Angsila) 0.37 ± 0.03 (Bangsaen) 0.43 ± 0.04 (Samaesarn)	Thailand (coastal)	Thushari *et al.* (2017)
	Scapharca cornea	120	NaOH	FTIR	-	557.98 (Station 1) 261.22 (Station 2) 86.27 (Station 3)	Malaysia (coastal)	Ibrahim *et al.* (2016)
Cephalopoda	*Loligo* sp.	90	KOH	Observation	6.13 ± 6.53 (Pasar Peterongan) 6.16 ± 6.58 (Pasar Bulu) 6.35 ± 6.61 (Pasar Johar) 5.13 ± 3.14 (Pasar Bangetayu) 4.66 ± 3.36 (Pasar Karangayu) 2.22 ± 2.31 (Pasar Rejomulyo)	3.31 ± 3.88 (Pasar Peterongan) 2.60 ± 2.52 (Pasar Bulu) 1.69 ± 1.81 (Pasar Johar) 1.78 ± 1.13 (Pasar Bangetayu) 1.40 ± 1.28 (Pasar Karangayu) 0.77 ± 0.84 (Pasar Rejomulyo)	Indonesia (traditional market)	Angganararas (2019)
Echinoidea	*Diadema* sp.	10	KOH	Observation	22.3	-	Indonesia (island)	Lolodo and Nugraha (2019)
	Tripneustes gratilla	17	KOH	Observation	0.5	-	Indonesia (islands)	Tahir *et al.* (2019)
Gastropoda	*Cerithidea obtusa*	20	HNO_3	Observation	167 ± 16.01	-	Indonesia (mangrove)	Fitri and Patria (2019b)
	Chicoreus capucinus	14	HNO_3	FTIR	0.25 to 0.88	0.50 to 1.75	Malaysia (estuary)	Zaki *et al.* (2021)
	Cypraea tigris	10	KOH	Observation	0.3		Indonesia (islands)	Tahir *et al.* (2019)
	Dolabella auricularia	8	HNO_3	Observation	-	54.9	Indonesia (island)	Priscilla *et al.* (2019)

Table 1. Continued.

Class	Species	Number of samples (n)	Chemical for extraction	Identification	Concentration (mean ± SD)		Country & Sampling area type	References
					Particles/ individual	Particles/ gram		
Gastropoda	*Laevistrombus turturella*	40	HNO_3	Observation	492 ± 107.68 (Station 1) 476 ±171.34 (Station 2) 360 ±118.43 (Station 3) 628 ±191.93 (Station 4)	-	Indonesia (island)	Hamra and Patria (2019)
	Littoraria scabra	10	HNO_3	Observation	75.5 ± 26.24	86.88 ± 12.00	Indonesia (island)	Patria *et al.* (2020)
	Littoraria sp.	150	HNO_3	Raman	-	0.23 ± 0.02 (Angsila) 0 (Bangsaen) 0.17 ± 0.08 (Samaesarn)	Thailand (coastal)	Thushari *et al.* (2017)
	Nerita articulata	67	HNO_3	FTIR	0.25 to 0.88	0.50 to 1.75	Malaysia (estuary)	Zaki *et al.* (2021)
	Nerita polita	14	HNO_3	FTIR	0.25 to 0.88	0.50 to 1.75	Malaysia (estuary)	Zaki *et al.* (2021)
	Nudibranch	6	KOH	Observation	0	-	Indonesia (islands)	Tahir *et al.* (2019)
Hexanauplia	Calanoid (zooplankton)	10-700	HNO_3	Observation	0.14	-	Malaysia (sea)	Amin *et al.*, (2020)
	Cyclopoid	10-700	HNO_3	Observation	0.007	-	Malaysia (sea)	Amin *et al.*, (2020)
Malacostraca	*Litopenaues vannamei*	90	H_2O_2	ATR-FTIR	5.60 ± 3.90 (Pasar Bulu) 8.67 ± 5.36 (Pasar Peterongan) 9.92 ± 7.84 (Pasar Johar) 7.10 ± 5.37 (Pasar Bangetayu) 8.43 ± 5.15 (Pasar Karangayu) 11.57± 6.69 (Pasar Waru Indah)	1.20 ± 0.98 (Pasar Bulu) 2.02 ± 1.43 (Pasar Peterongan) 2.58 ± 2.33 (Pasar Johar) 1.62 ± 1.10 (Pasar Bangetayu) 1.87 ± 1.19 (Pasar Karangayu) 2.98 ± 2.21 (Pasar Waru Indah)	Indonesia (traditional market)	Sudianto (2019)
	Metapenaeus brevicornis	18	KOH	FTIR	3.78 ± 1.12	0.76 ± 0.48	Thailand (traditional market)	Pradit *et al.* (2021)
	Metopograpsus quadridentate	9	HNO_3	Observation	-	61.44 (Station 1) 69.54 (Station 2) 47.76 (Station 3)	Indonesia (mangrove)	Petala and Tsabita (2018)
		9	HNO_3	Observation	327.56 ± 147.98	33 ± 6.72	Indonesia (island)	Patria *et al.* (2020)
	Parapenaeopsis hardwickii	18	KOH	FTIR	4.11 ± 1.12	0.55 ± 1.19	Thailand (traditional market)	Pradit *et al.* (2021)
	Penaeus merguiensis	60	KOH	Observation	4.66 ± 3.95	-	Indonesia (coastal)	Restiani (2017)

Table 1. Continued.

Class	Species	Number of samples (n)	Chemical for extraction	Identification	Concentration (mean ± SD)		Country & Sampling area type	References
					Particles/ individual	Particles/ gram		
Malacostraca	*Scylla* spp.	90	H_2O_2	Observation	49.54 ± 21.40 (Pasar Peterongan) 69.60 ± 36.18 (Pasar Tanah Mas) 49.84 ± 13.83 (Pasar Gang Baru) 45.59 ± 15.73 (Pasar Bangetayu) 42.83 ± 10.81 (Pasar Kobong) 34.39 ± 15.77 (Pasar Karang Ayu)	9.09 ± 4.65 (Pasar Peterongan) 12.52 ± 5.98 (Pasar Tanah Mas) 9.62 ± 4.03 (Pasar Gang Baru) 9.58 ± 4.58 (Pasar Bangetayu) 7.92 ± 4.32 (Pasar Kobong) 6.14 ± 2.95 (Pasar Karang Ayu)	Indonesia (traditional market)	Adidharma (2019)
	Shrimp (zooplankton)	10-700	HNO_3	Observation	0.13	-	Malaysia (sea)	Amin *et al.* (2020)
Polychaeta	Polychaete (zooplankton)	10-700	HNO_3	Observation	0.01	-	Malaysia (sea)	Amin *et al.* (2020)
Sagittoidea	Chaetognaths	10-700	HNO_3	Observation	0.003	-	Malaysia (sea)	Amin *et al.* (2020)
Thecostraca	*Balanus amphitrite*	150	HNO_3	Raman	-	0.43 ± 0.33 (Angsila) 0.33 ± 0.04 (Bangsaen) 0.23 ± 0.10 (Samaesarn)	Thailand (coastal)	Thushari *et al.* (2020)

an extended period. Therefore, while *S. cornea* is a bivalve species with a pseudofeces mechanism, the situation of the location will also be affecting the bivalve's vulnerability to microplastics ingestion. Although species could originate from the same class that will determines their feeding behavior, different studies have different location, and chemical for extraction that causes variation of microplastic concentration values.

Amin, Sohaimi, Anuar, and Bachock (2020) revealed a low incidence of ingestion in zooplankton groups at the coast of Terengganu, Malaysia. This suggests that zooplankton may mistake microplastics for food, raising concerns about the potential for trophic transfer to predatory species at higher trophic levels (Egbeocha *et al.*, 2018).

4. Dominant Colors and Types of Microplastics

From 33 literatures, 15 assessed the color of microplastic ingestion in marine invertebrates. Only 13 studies (39.39%) documented the dominant microplastic color. Tahir *et al.* (2019) listed two dominant colors for his study, which were blue and black. Figure 2 shows black is the most common dominant color to be discovered in microplastics identified in marine invertebrates. In contrast to Hidalgo-Ruz, Gutow, Thompson, and Thiel (2012) that mentioned the most prevalent color of microplastics in sediment and seawater were white or shades of white. This could indicate that marine invertebrates could potentially have color preferences behavior when foraging the microplastics. Zaki *et al.* (2021) stated that dark colors, such as blue, brown, and black are ingested by the gastropods *N. articulata*, *N. polita* and *Chicoreus capucinus* due to the microplastics having the appearance of food compared to light colors. Black microplastics often associated with polystyrene (PS) and polypropylene (PP) polymers and it could adsorb more variety of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) (Frias, Sobral, & Ferreira, 2010; Hidalgo-Ruz *et al.*, 2012; Ichlasia, 2017).

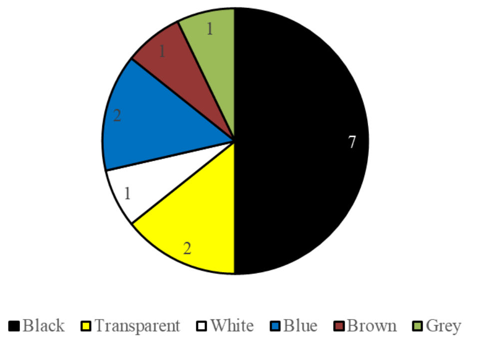

Figure 2. Dominant colors of microplastics ingestion in marine invertebrates recorded. Numbers in the figure are numbers of publications

Visual identification of microplastics cannot be done only based on color because the color of microplastic does not determine the polymer and chemical composition (Ibrahim *et al*., 2016; Lusher, Welden, Sobral, & Cole, 2017). However, recording microplastic color is vital for investigations involving marine invertebrates to investigate color preference behavior (Frias & Nash, 2018).

From out 33 literatures, 28 assessed types of microplastic ingestion in marine invertebrates. While 27 (81.82%) studies documented the dominant microplastic type, Thushari *et al.* (2017) just listed the types of plastics found without mentioning the dominant type. Fibre is the most prevalent type of microplastic found in marine invertebrates (Figure 3). This present finding seems to be consistent with Phuong *et al*. (2016) which recognized fiber microplastics were widely indicated in marine invertebrates. Fiber is a secondary source of microplastics originated from the synthetic materials of clothes and monofilament fragmentation of fishing nets and ropes (Hidalgo-Ruz *et al*., 2012; Rochman *et al*., 2019). The dominance of fiber could be explained as the sampling locations located near to the fishing activities of the local community (Fachruddin, Yaqin, & Iin, 2020; Hamra & Patria, 2019; Hardianti, 2019; Ichlasia, 2017; Lolodo & Nugraha, 2019; Sari, 2018; Tharamon *et al*., 2016). The abundance of fisheries activities contributed to the source of microplastic fiber from fishing net. Meanwhile, another reason for the prevalent of fiber could be due to ecotourism activities and settlement along the coast (Hamra & Patria, 2019). Patria, Santoso and Tsabita (2020) conducted her research on Pramuka Island, Indonesia a popular ecotourism destination and discovered that the most common type of microplastic in *M. quadridentata* and *Littoraria scabra* was microplastics fibre. The microplastics fiber could come from the clothing worn by people partaking in the water activities and wastewater of the nearby chalet and resort.

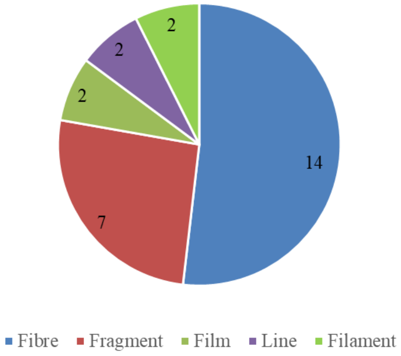

Figure 3. Dominant types of microplastics ingestion in marine invertebrates recorded. Numbers in the figure are numbers of publications

5. Lab-based Studies of Microplastic Ingestion in Marine Invertebrates

Two papers conducted studies in laboratories to control the environment of marine invertebrates. Rahim, Yaqin, and Rukminasari (2019) showed that the ingestion of PE microplastics in *P. viridis* increases as the concentration of PE microplastics in water increases and caused mortality. This is consistent with what has been obtained by Qu, Su, Li, Liang, and Shi (2018), the number of microplastics in *P. viridis* was significantly higher in high concentration treatments compared to low concentration treatments.

Another laboratory experiment, Syakti *et al.* (2019) showed the bleaching and necrosis events happened to *Acropora* sp. when exposed to treatments of low-density polyethylene (LDPE). These findings seem to be consistent with other research that found similar events happened to *Acropora* sp.when exposed to microplastics (Reichert, Arnold, Hoogenboom, Schubert, & Wilke, 2019; Reichert, Schellenberg, Schubert, & Wilke, 2018). These effects were thought to be caused by the reduction in light penetration due to the microplastics covering the surface of the coral or the toxicity of the microplastics itself. However, further work is still required to establish the presence of a mechanism for both theories.

6. Microplastic Challenges/Limitation Studies on Southeast Asia

There is unequal distribution of microplastic ingestion in marine invertebrates' research across Southeast Asia. While sharing the same ocean waters and marine invertebrate species, there may be a knowledge gap between countries. Without the creation of a regional database for marine invertebrate research, it becomes harder to obtain the newest critical information by researchers across Southeast Asia (Lyons *et al*., 2019).

Next, Southeast Asia's seas is a site to the coral triangle, which has 76% of the world's total species composition of corals (Cros *et al*., 2014) as well as a habitat for diverse range of other marine invertebrates. Microplastic ingestion has been proven to affect the coral reefs (Reichert *et al*., 2018, 2019; Syakti *et al*., 2019). The collapse of the coral reef ecosystem would threaten 130 million people who rely on these marine resources for their livelihoods (Lasut *et al*., 2018).

Lastly, microplastics have been shown to pose a problem to seafood food security in both wild and farmed populations. The current research also still tends to focus on species that is edible and have commercial significance. This priority will cause humans to overlook the other marine invertebrates that already ingested more microplastics compared to the commercial species (Priscilla, Sedayu & Patria, 2019; Patria *et al*., 2020).

7. Conclusions

This review demonstrated that the majority of microplastic ingestion in marine invertebrates' investigations have been undertaken in Indonesia, with species primarily from the Java Sea. Most of the chosen species are economically significant and edible, the concentration of microplastics ingested can be influenced by feeding behavior, and species location. Although most researchers focus on gastropod and bivalve as the subject of research, other types of marine invertebrates also should be considered for future study. The dominant type, color and the polymer of microplastics could give information of the microplastic sources and anthropogenic activities that occurred nearby. It is important to conduct further studies to determine if the toxicity effects are connected to the presence of microplastic, the polymer's composition, or the shape and colors of the microplastics instead.

Acknowledgements

Authors gratefully acknowledge the Special MyRA Assessment Funding from Universiti Malaysia Sarawak (Funding ID: F07/SpMYRA/1711/2018).

References

Adidharma, Y. S. (2019). *Microplastics identification of mud crab's gastrointestinal tracts (Scylla sp.) from traditional market in Semarang* (Master's thesis, Universitas Katolik Seogijapranata, Semarang, Indonesia).

Amin, R. M., Sohaimi, E. S., Anuar, S. T. & Bachok, Z. (2020). Microplastic ingestion by zooplankton in Terengganu coastal waters, southern South China Sea. *Marine Pollution Bulletin, 150*.

Angganararas, M. (2019). *Microplastics identification in squid from traditional market in Semarang* (Master's thesis, Universitas Katolik Seogijapranata, Semarang, Indonesia).

Argamino, C. R. A. & Janairo, J. I. (2016). Qualitive assessment and management in Asian green mussels (*Perna viridis*) cultured in Bacoor Bay, Cavite, Phillipines. *Environment Asia*, *9*(2), 48–54.

Bonanno, G. & Orlando-Bonaca, M. (2018). Perspectives on using marine species as bioindicators of plastic pollution. *Marine Pollution Bulletin, 137*, 209-221.

Centre for Agriculture and Bioscience International. (2019). *Perna viridis* (Asian green mussel). Retrieved from https://www.cabi.org/isc/datasheet/70090 #tosummaryOfInvasiveness

Cros, A., Fatan, N. A., White, A., Teoh, S. J., Tan, S., Handayani, C., . . . Beare, D. (2014). The coral triangle atlas: An integrated online spatial database system for improving coral reef management. *PLos One, 9*(6).

Ding, J., Sun, C., He, C., Li, J., Ju, P. & Li, F. Microplastics in four bivalve species and basis for using bivalves as bioindicators of microplastic pollution. *Science of The Total Environment, 782*.

Egbeocha, C. O., Malek, S., Emenike, C. U. & Milow, P. (2018). Feasting on microplastics: Ingestion by and effects on marine organisms. *Aquatic Biology, 27*, 93-106.

El, N. H., Daud, A., Tahir, A., Mallongi, A., Amqam, H. & Salam, A. (2020). Microplastic exposure through mussels consumption in the coastal area community of Pa'lalakkang Village, Galesong, Takalar district. *South Asian Research Journal of Biology and Applied Biosciences*, *2*(5), 109–113.

Espiritu, E. Q., Dayrit, S. A. S. N., Coronel, A. S. O., Paz, N. S. C., Ronquillo, P. I. L., Castillo, V. C. G. & Enriquez, E. P. (2019). Assessment of quantity and quality of microplastics in the sediments, waters, oysters and selected fish species in key sites along the Bombong Estuary and the coastal waters of Ticalan in San Juan, Batangas. *Philippine Journal of Science*, *148*(4), 789–816.

Fachruddin, L., Yaqin, K. & Iin, R. (2020). Perbandingan dua metode analisis konsentrasi mikroplastik pada kerang hijau, *Perna viridis* dan penerapannya dalam kajian ekotoksikologi. *Jurnal Pengelolaan Perairan*, *3*(1), 1–12.

Fitri, S. & Patria, M. P. (2019a). Microplastic contamination on *Anadara granosa* Linnaeus 1758 in Pangkal Babu mangrove forest area, Tanjung Jabung Barat district, Jambi. *Journal of Physics: Conference Series 1282*, 012109.

Fitri, S. & Patria, M. P. (2019b). Microplastic contamination on *Cerithidea obtusa* (Lamark 1822) in Pangkal Babu mangrove forest area, Tanjung Jabung Barat district, Jambi. *AIP Conference Proceedings 2168*, 020075.

Frias, J. P. G. L., Sobral, P. & Ferreira, A. M. (2010). Organic pollutants in microplastics from two beaches of the Portuguese coast. *Marine Pollution Bulletin*, *60*(11), 1988–1992.

Frias, J. P. G. L & Nash, R. (2018). Finding a consensus on the definition. *Marine Pollution Bulletin, 138*, 145–147.

Hamra, A. J. A. & Patria, M. P. (2019). Microplastic in Gonggong snails (*Laevistrombus turturella*) and sediment of Bintan Island, Kepulauan Riau Province, Indonesia. *AIP Conference Proceedings 2202*, 020079.

Hardianti, D. (2019). *Identifikasi kandungan mikroplastik pada kerang hijau (Perna viridis) dan kerang tahu (Meretrix meretrix) di Teluk Jakarta* (Master's thesis, Universitas Sriwijaya, Inderalaya, Indonesia).

Hidalgo-Ruz, V., Gutow, L., Thompson, R. C. & Thiel, M. (2012). Microplastics in the marine environment: A Review of the methods used for identification and quantification. *Environmental Science and Technology*, *46*(6), 3060–3075.

Horn, D., Miller, M., Anderson, S. & Steele, C. (2019). Microplastics are ubiquitous on California beaches and enter the coastal food web through consumption by Pacific mole crabs. *Marine Pollution Bulletin, 139*, 231–237.

Ibrahim, Y. S., Azmi, A. A., Shukor, S. A., Anuar, S. T. & Abdullah, S. A. (2016). Microplastic ingestion by *Scapharca cornea* at Setiu Wetland, Terengganu, Malaysia. *Middle-East Journal of Scientific Research*, *24*(6), 2129–2136.

Ichlasia, A. N. (2017). *Initial study of microplastic on blood cockle (Anadara granosa) from Tambak Lorok Semarang* (Universitas Katolik Seogijapranata, Semarang, Indonesia).

Jamieson, A. J., Brooks, L. S. R., Reid, W. D. K., Piertney, S. B., Narayanaswamy, B. E. & Linley, T. D. (2019). Microplastics and synthetic particles ingested by deep-sea amphipods in six of the deepest marine ecosystems on Earth. *Royal Society Open Science, 6*(2).

Lasut, M. T., Weber, M., Pangalila, F., Rumampuk, N. D. C., Rimper, J. R. T. S. L., Warouw, V., Kaunang, S. T. & Lott, C. (2018). From coral triangle to trash triangle-How the hot spot of global marine biodiversity is threatened by plastic waste. In M. Cocca., E. Di Pace., M. Errico., G. Gentile., A.

Montarsolo., & R. Mossotti (Eds.), *Proceedings of the international conference on microplastic pollution in the Mediterranean Sea* (pp. 107–113). Switzerland: Springer.

Lolodo, D. & Nugraha, W. A. (2019). Microplastics on sea urchine from Sumenep Labak Gili Islands. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, *12*(2), 112–122.

Lusher, A. L., Welden, N. A., Sobral, P. & Cole, M. (2017). Sampling, isolating and identifying microplastics ingested by fish and invertebrates. *Analytical Methods*, *9*(9), 1346–1360.

Lyons, Y., Linting, S, T. & Neo, M. L. (2019). *A review of research on marine plastics in Southeast Asia: Who does what?*. Singapore: National University of Singapore.

Lyons, Y., Neo, M. L., Lim, A., Tay, Y. L. & Dang, V. H. (2020). *Status of research, legal and policy efforts on marine plastics in Asean+3: A gap analysis at the interface of science, law and policy*. Singapore: National University of Singapore.

Macali, A., & Bergami, E. (2020). Jellyfish as innovative bioindicator for plastic pollution. *Ecological Indicators, 115.*

Maha, R. R. (2019). *Microplastic contamination in green mussel aquaculture at Straits of Johor* (Master's thesis, University Teknologi Malaysia, Johor, Malaysia).

Nam, P. N., Tuan, P. Q., Thuy, D. T., Quynh, L. T. P. & Amiard, F. (2019). Contamination of microplastic in bivalve: First evaluation in Vietnam. *Vietnam Journal of Earth Sciences, 41*(3), 252–258.

Nezaputri, N. A., Kurniawan, D., Suryanti, A., Muzahar & Susiana. (2021). Food and feeding habits of Dog Conch (*Laevistrombus turturella*) on Penyengat Island, Tanjungpinang. *Oseanologi dan Limnologi di Indonesia, 6*(1), 1–10.

Nurulchusna, A. A. (2018). *Isolation, identification and quantification of microplastics in green mussels from three traditional markets in Semarang* (Master's thesis, Universitas Katolik Seogijapranata, Semarang, Indonesia).

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.

Petala, M. & Tsabita, N. (2018). Abundance of microplastics in the water and mangrove crab *Metopograpsus quadridentata* in Pramuka Island, Jakarta. *International Seminar on Bioscience and Biological Education*, Yogyakarta, Indonesia.

Phuong, N. G., Zalouk-Vergnoux, A., Poirier, L., Kamari, A., Châtel, A., Mouneyrac, C. & Fabienne, L. (2016). Is there any consistency between the microplastics found in the field and those used in laboratory experiments?. *Environmental Pollution*, *211*, 111–123.

Priscilla, V., Sedayu, A. & Patria, M. P. (2019). Microplastics abundance in the water, seagrass, and sea hare *Dolabella auricularia* in Pramuka Island, Seribu Islands, Jakarta Bay, Indonesia. *Journal of Physics: Conference Series 1402*, 033073.

Pradit, S., Noppradit, P., Goh, B. P., Sornplang, K., Ong, M. C. & Towatana, P. (2021). Occurrence of microplastics and trace metals in fish and shrimp from Songkhla Lake, Thailand during the COVID-19 pandemic. *Applied Ecology and Environmental Research*, *19*(2), 1085-1106.

Qu, X., Su, L., Li, H., Liang, M. & Shi, H. (2018). Assessing the relationship between the abundance and properties of microplastics in water and in mussels. *Science of the Total Environment*, *621*, 679–686.

Rahim, N. F., Yaqin, K. & Rukminasari, N. (2019). Effect of microplastic on green mussel *Perna Viridis*: Experimental approach. *Jurnal Ilmu Kelautan, 5*(2), 89–94.

Reichert, J., Schellenberg, J., Schubert, P. & Wilke, T. (2018). Responses of reef building corals to microplastic exposure. *Environmental Pollution, 237*, 955–960.

Reichert, J., Arnold, A. L., Hoogenboom, M. O., Schubert, P. & Wilke, T. (2019). Impacts of microplastics on growth and health of hermatypic corals are Species-specific. *Environmental Pollution, 254*.

Richie, H. & Roser, M. (2018). Plastic pollution - Our world in data. Retrieved from https://ourworldindata.org/plastic-pollution?utm_source=newsletter

Rochman, C. M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., . . . Hung, C. (2019). Rethinking microplastics as a diverse contaminant. *Environmental Toxicology and Chemistry, 38(4),* 703–711.

Sari, K. (2018). Occurrence of microplastics in filter feeder animal on seagrass in at Spermonde Achipelago Makassar. (Master's thesis, Universitas Hasanuddin, Makassar, Indonesia).

Setälä, O., Norkko, J. & Lehtiniemi, M. (2016). Feeding type affects microplastic ingestion in a coastal invertebrate community. *Marine Pollution Bulletin, 1*, 95–101.

Sudianto, N. P. (2019) *Identifikasi dan kuantifikasi polimer mikroplastik pada udang vannamei (Litopenaeus vannamei) dari pasar tradisional Kota Semarang Indonesia* (Master's thesis, Universitas Katolik Soegijapranata, Semarang, Indonesia).

Supratman, O. & Tati, S. S. (2018). Karakteristik habitat siput gonggong (*Strombus turturella*) di ekosistem Padang Lamun. *Jurnal Kelautan Tropis, 21*(2), 81–90.

Syakti, A. D., Jaya, J. V., Rahman, A., Hidayati, N. V., Raza'I, T. S., Idris, F., Trenggono, M., Doumenq, P. & Chou, L. M. (2019). Bleaching and necrosis of staghorn coral (*Acropora Formosa*) in laboratory assays: Immediate impact of LDPE microplastics. *Chemosphere, 228*, 528–535.

Tahir, A., Samawi, M. F., Sari, K., Hidayat, R., Nimzet, R., Wicaksono, E. A., Asrul, L. & Werolilangi, S. (2019). Studies on microplastic contamination in seagrass beds at Spermonde Archipelago of Makassar Strait, Indonesia. *Journal of Physics: Conference Series 1341*, 02208.

Tharamon, P., Praisankul, S. & Leadprathon, N. (2016). Contamination of microplastic in bivalve at Chaolao and Kungwiman beach Chanthaburi Province. *Khon*

Kaen Agriculture Journal.

Thushari, G. G. N., Senevirathna, J. D. M., Yakupitiyage, A. & Chavanich, S. (2017). Effects of microplastics on sessile invertebrates in the Eastern coast of Thailand: An approach to coastal zone conservation. *Marine Pollution Bulletin*, *124*(1), 349–355.

Ward, J. E., Zhao, S., Holohan, B. A., Mladinich, K. M., Griffin, T. W., Wozniak, J. & Shumway, S. E. (2019). Selective ingestion and egestion of plastic particles by the blue mussel (*Mytilus edulis*) and eastern oyster (Crassostrea *virginica*): Implications for using bivalves as bioindicators of microplastic pollution. *Environmental Science and Technology*, *53*(15), 8776-8784.

Zaki, M. R. M., Zaid, S. H. M., Zainuddin, A. H. & Aris, A. Z. (2021). Microplastics pollution in tropical estuary gastropods: Abundance, distribution and potential sources of Klang river estuary, Malaysia. *Marine Pollution Bulletin*, *162*.

Zhao, S., Ward, J. E., Danley, M. & Mincer, T. J. (2018). Field-based evidence for microplastic in marine aggregates and mussels: Implications for trophic transfer. *Environmental Science and Technology*, *52*(19), 11038-11048.