ORIGINAL PAPER

Microplastic ingestion by zooplankton in Ko Sichang, Chonburi Province

Sirirat jaihan[a], Makamas Sutthacheep[a*], Sitiporn Pengsakun, Duangkamon Sangiamdee[b] and Thamasak Yeemin[a]

[a]Marine Biodiversity Research Group, Department of Biology, Faculty of Science, Ramkhamhaeng University, Huamark, Bangkok 10240, Thailand
[b]Department of Chemistry, Faculty of Science, Ramkhamhaeng University, Huamark, Bangkok 10240, Thailand

*Corresponding author: *smakamas@hotmail.com*

Received: 10 December 2021 / Revised: 30 December 2021 / Accepted: 30 December 2021

Abstract. Microplastics (particles size less than 5 mm) have become serious pollution from anthropogenic activities in the marine ecosystem. Marine organisms ingest microplastic has been widely reported e.g., muscle, worm, fish, sea bird. However, the primary consumer as zooplankton can ingest microplastic and accumulate through a high level of marine food webs. The present research investigated microplastics ingested by different zooplankton groups at Ko Sichang. Particles of microplastic were analyzed under a stereomicroscope and identified by using Fourier transform infrared spectroscopy (FTIR). The analytical results showed that fibrous microplastics were detected at all dominant zooplankton groups. These groups include calanoid copepods, cyclopoid copepods, crustacean nauplii, and gastropod larvae where they ingested 0.64, 0.45, 0.91, and 0.55 particles per individual, respectively. The average size of microplastic in zooplankton was 488.50±255.52 µm. Polyethylene terephthalate (PET) Polypropylene (PP) and polyethylene (PE) are the most common type of microplastic were found in zooplankton samples. Based on the findings, it may be utilized as an indicator for assessing the ecological risk of microplastics in marine organisms. This is a threat to higher levels of the food chain, including humans. It is crucial to conduct a risk assessment of microplastics on the ecosystem, social and economic levels.

Keywords: microplastic, copepods, zooplankton, Gulf of Thailand, plastic debris

1. Introduction

For seven decades, humans across the world have been increasingly using plastics for various purposes and activities, leading to the continuous growth of global plastic production. In 2020, about 367 million metric tonnes (Mt) of plastics were produced globally (Plastics Europe 2021). Plastic waste tends to unavoidably occur due to the increased consumption of plastics. In a business-as-usual scenario, it was estimated that the number of plastic waste could reach 155–265 Mt y^{-1} by 2060 (Lebreton and Andrady 2019). Without having a proper waste management system, unmanaged plastic waste may contaminate rivers and further discharge to the sea. Jambeck et al. (2015) estimated that about 2-5% of total waste generated in coastal countries was mismanaged, ultimately contributing to marine debris.

Over time, plastics can be gradually degraded and fragmented into smaller pieces through various weathering processes, including UV exposure, biodegradation, and physical and chemical degradation (Browne et al. 2007; Andrady 2011). Generally, plastic particles of smaller than 5 mm are recognized as microplastics. Because of their tiny size, microplastics can be contaminated into various marine species, ranging from planktonic invertebrates to large marine mammals (GESAMP, 2015). The Convention on Biological Diversity (CBD) reported that more than 800 species of marine organisms were affected by marine debris, mostly through entanglement and ingestion, and over 80% of these effects were associated with plastics, as detected in bivalves, polychaetes, crustaceans, fish, and sea birds (Murray and Cowie 2011; Van Cauwenberghe and Janssen 2014; Li et al. 2016; Lusher et al. 2016; Zhao et al. 2016; Jang et al. 2018). Having various chemicals, microplastics may have physical and chemical effects on these organisms, for example, blocking the alimentary tract upon ingestion, chemical contamination etc (Wright et al. 2013; Rochman et al. 2013; Ivar do Sul and Costa 2014).

Some reports indicated that various invertebrates ingest microplastics, including planktonic organisms such as copepods, larval fish etc. (Cole et al. 2013; Lönnstedt and Eklöv 2016). Zooplankton plays an essential role in marine ecosystems by linking the primary producers and the higher trophic levels, thus contributing ecological benefits to the marine food web. The ingestion of microplastics by zooplankton may pose a risk on the contamination of the marine food web caused by such microplastics can be transferred to higher trophic levels along the food chain, eventually linked to the safety of fisheries products and human health. It is thus essential to understand the ingestion and transfer of microplastics by different groups of zooplankton in natural seawater in order to lay a foundation for the ecological risk assessment of microplastics in natural ecosystems (Sun et al. 2017). Therefore, this study aimed to investigate microplastics ingested by different groups of zooplankton at Ko Sichang, Chonburi Province, the Upper Gulf of Thailand.

2. Materials and Methods

2.1 Study sites and sample collection

Koh Sichang (Sichang Island) is in an administrative boundary of Chonburi Province, consisting of small islands located in the inner part of the eastern seaboard of the Gulf of Thailand (13°09 N, 100°49 E) as shown in Figure 1. The sampling sites were in the western coast of Ko Sichang. Zooplankton sampling was conducted by vertical tows with 120 µm mesh plankton net and 30 cm in diameter about 1-5 m in depth. Zooplankton samples were preserved in 10% buffered formalin solution and then transported to the marine biodiversity research group laboratory for further analysis.

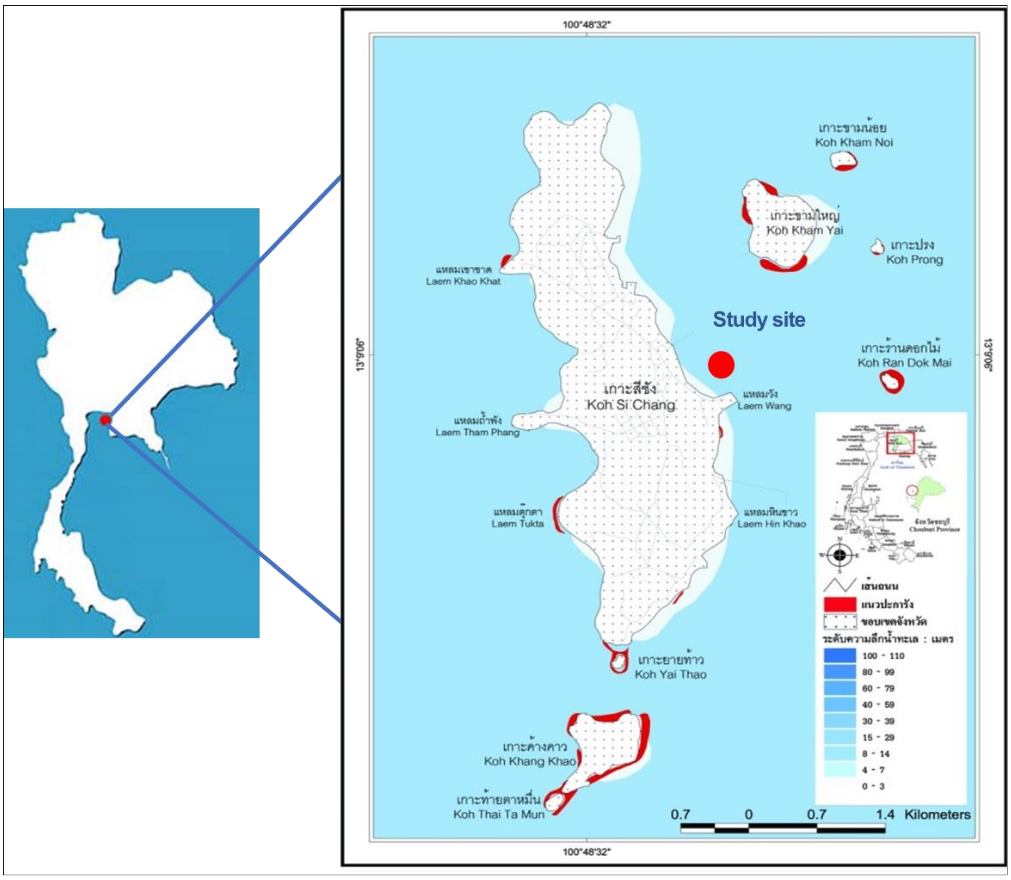

Figure 1. Location of study site

2.2 Microplastics extraction

Four dominant zooplankton groups were picked out from the zooplankton samples under a stereomicroscope at least 20 individuals of each zooplankton group. The zooplankton samples were watched with purified water three times to ensure no plastic was attached to their body surface. The samples were digested by a 30% hydrogen peroxide (H_2O_2) solution with a temperature of 60 °C about 12-48 h, to remove soft tissues. Microplastics in zooplankton samples were separated by filtration of the solution using a vacuum system through 20 µm pore size filter and 75 mm in diameter (Whatman PLC 122 United Kingdom) (Li et al. 2015). After 24 h of floatation at room temperature, the overlying water was vacuum filtered through a 20 µm pore size filter.

2.3 Statistical analysis

The abundance of microplastics was expressed as a mean density with a standard deviation of microplastics found in each group of zooplankton. One-way Analysis of Variance (ANOVA) was used to detect the difference in abundance of microplastics among the groups of zooplankton. All analyses were performed using R program version 3.5.0.

3. Results

In this study, we determined the abundance of microplastics in four groups of zooplankton, including cyclopoid copepods, calanoid copepods, crustacean nauplii and gastropod larvae (Figure 2). Our analytical results revealed that fibre microplastics were detected in all dominant zooplankton groups. We further found that such microplastics were Polyethylene terephthalate (PET) and Polypropylene (PP), according to the confirmatory analysis using Fourier-transform infrared spectroscopy (FTIR).

The highest abundance of microplastics was found in crustacean nauplii (0.91± 1.14 particles.ind^{-1}), followed by calanoid copepods (0.64± 1.67 particles.ind^{-1}), gastropods (0.55± 0.52 particles.ind^{-1}). The lowest abundance was found in cyclopoid copepods (0.45± 0.52 particles.ind^{-1}) (Figure 3). Due to a high variation of microplastic abundance, no significant difference in the microplastic abundance among groups of zooplankton was found ($p>0.05$).

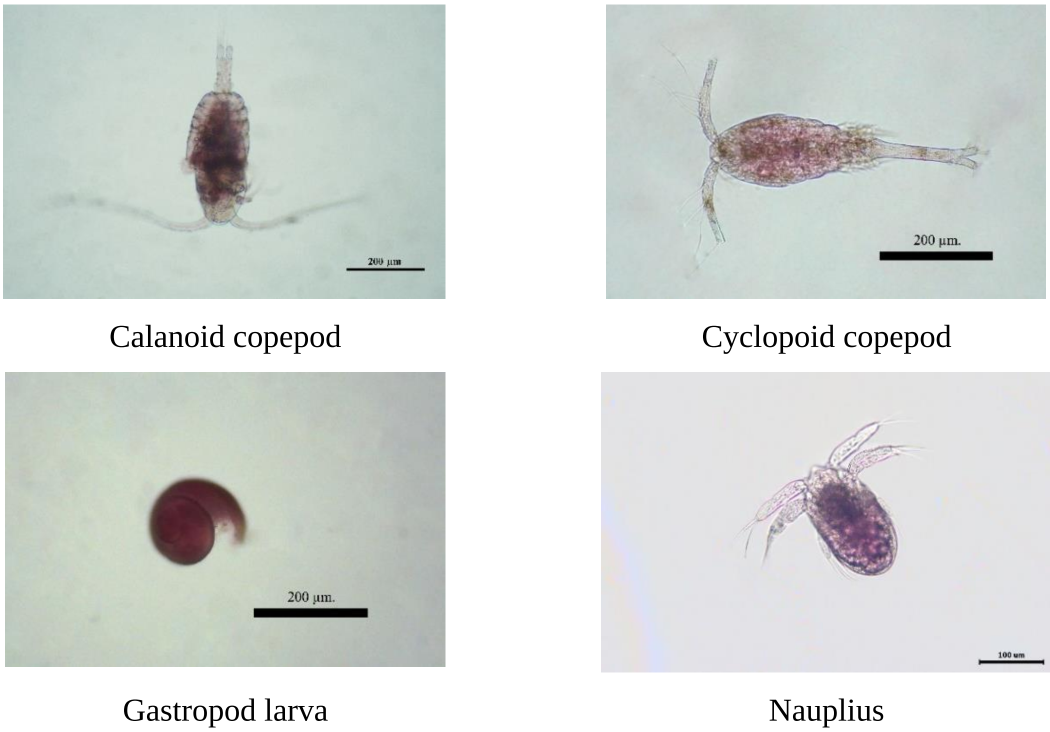

Figure 2. The dominant groups of zooplankton found at Ko Sichang

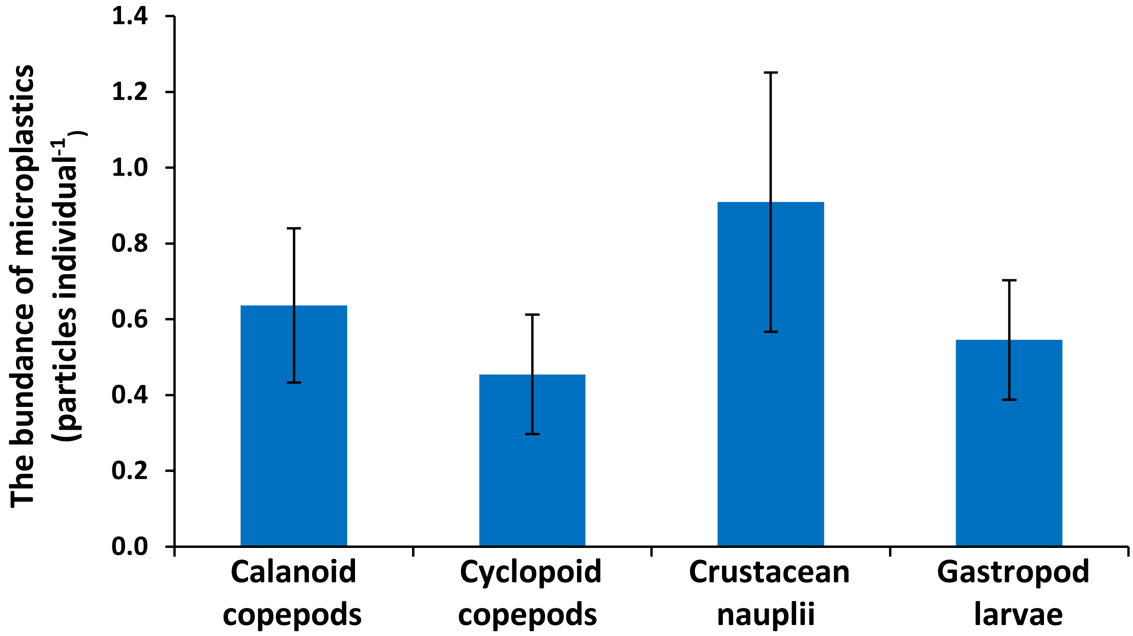

Figure 3. The abundance of microplastics in zooplankton groups

Considering the proportion of microplastic types in each group of zooplankton, polypropylene (PP) shows the highest proportion for all groups of zooplankton, except in gastropods where polypropylene (PP) and Polyethylene terephthalate (PET) were found equally. Polypropylene was found as a major component of microplastics in crustacean nauplii, calanoid copepods, and cyclopoid copepods, accounting for 71%, 70%, and 60%, respectively (Figure 4).

4. Discussion

Plastic debris can be digested into tiny particles (<5mm). Microplastics can enter the marine and coastal ecosystems from the discharge of untreated wastewater used in clothing and cosmetic beads (Thompson 2015; Napper and Thompson 2016). Zooplankton can ingest microplastics resulting in microplastic accumulation in its body. The microplastics ingestion by zooplankton has been widely reported (Cole et al. 2013; Frias et al. 2014; Setälä et al. 2014; Desforges et al. 2015; Kosore et al. 2018; Coppock et al. 2019; Md Amin et al. 2020; Zheng et al. 2020). Based on our findings, zooplankton can be utilized as an indicator to assess the microplastic contamination in coastal and marine ecosystems. The contamination should be highly concerned as zooplanktons are the primary consumers in the marine food chain and microplastics can be transferred to other organisms at the higher trophic levels, including humans.

In the present study, we found that crustacean nauplius had the highest abundance of microplastics (0.91± 1.14 particles.ind^{-1}), which is similar to other reports. For example, a study on plastic contamination in nauplius larvae collected from Ao Bang Lamung, Chonburi Province also showed that nauplius had the highest abundance of microplastic (1.15 ±0.05 particles.ind^{-1}) compared to the other zooplankton groups (Buathong et al. 2020). Ko Sichang is an important economic island with several important maritime activities, which could be one of the major sources of plastic pollution. Polymer types found in zooplankton samples were polypropylene (PP) and Polyethylene terephthalate (PET). Those types of microplastics have been found in Thai waters (Chinfak et al. 2021). PP and PET are the important materials used for making food containers, plastic bottle, plastic bag, ropes, fishing gears, and textile industry (Park et al. 2004; Qiu et al. 2015; Liu et al. 2020).

Microplastics also affect other groups of zooplankton such as daphnids and copepods. The feeding rate and productivity of daphnids and copepods were significantly decreased due to an increased microplastic concentration (Yu et al. 2021). Moreover, zooplankton ingested on microplastics could reduce the grazing on a primary producer, increasing organic particle remineralization and leading to deoxygenation (Kvale et al., 2021). Based on the findings, zooplankton can be utilized as an indicator for assessing the ecological risk of microplastics in marine organisms. This study provides baseline information on microplastic contamination in zooplankton, which is useful for future research and stimulates public attention on the reduction of plastic consumption.

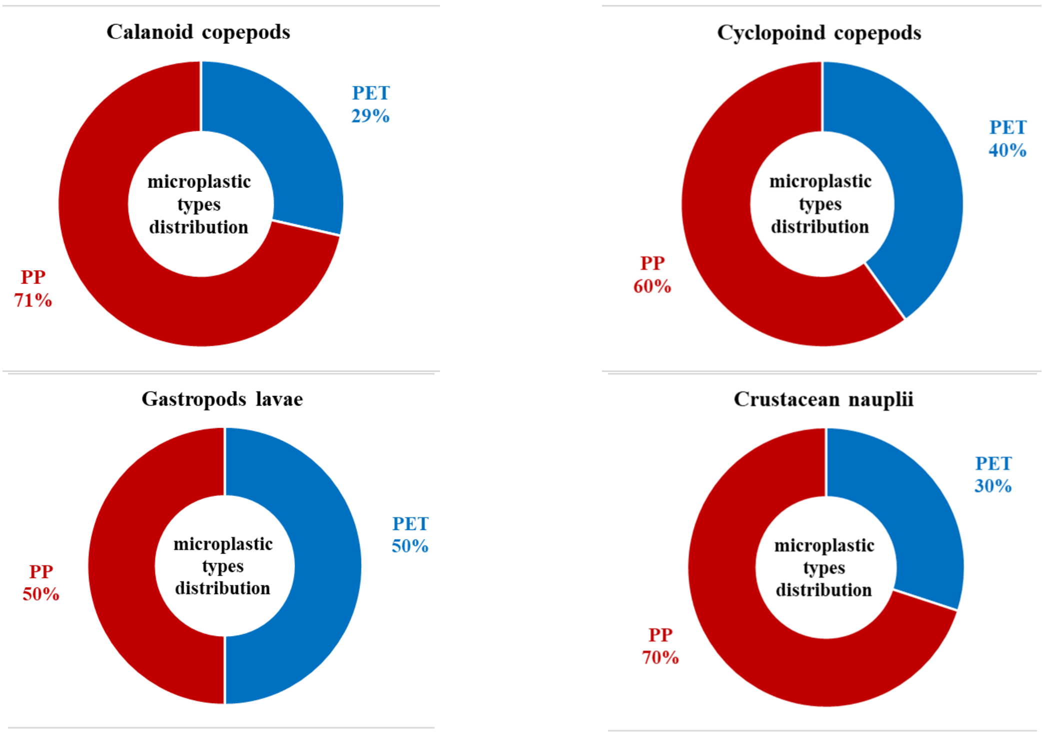

Figure 3. Proportion of microplastic types in zooplankton groups

Acknowledgements

Authors would like to thank the staff of Koh Sichang Marine Science Research Centre of Chulalongkorn University and the Marine Biodiversity Research Group, Faculty of Science, Ramkhamhaeng University for any supports during field surveys. This research was funded partly by a budget for research promotion from the Thai Government awarded to Ramkhamhaeng University. This paper is the one of the Thailand's project activities under the V2V Global Partnership.

References

Andrady AL (2011) Microplastics in the marine environment. Marine Pollution Bulletin 62: 1596 –1605

Browne MA, Galloway T, Thompson R (2007) Microplastic – an emerging contaminant of potential concern?. Integrated Environmental Assessment and Management 3: 559–561

Buathong D, Sriwisait P, Pnengsakun S, Chamchoy C (2020). Accumulation of microplastics in zooplankton from Chonburi Province, the Upper Gulf of Thailand. Ramkhamhaeng

International Journal of Science and Technology 3:1–12

Chinfak N, Sompongchaiyakul P, Charoenpong C, Shi H, Yeemin T, Zhang J (2021) Abundance, composition, and fate of microplastics in water, sediment, and shellfish in the Tapi-Phumduang River system and Bandon Bay, Thailand. Science of The Total Environment 781:146700

Cole M, Lindeque P, Fileman E, Halsband C, Goodhead R, Moger J, Galloway TS (2013) Microplastic Ingestion by Zooplankton. Environmental Science and Technology 47(12): 6646-6655

Cole M, Lindeque P, Fileman E, Halsband C, Goodhead R, Moger J, Galloway TS (2013) Microplastic ingestion by zooplankton. Environmental Science and Technology 47(12):6646–6655

Coppock RL, Galloway TS, Cole M, Fileman ES, Queirós AM, Lindeque PK (2019) Microplastics alter feeding selectivity and faecal density in the copepod, *Calanus helgolandicus*. Science of the Total Environment, 687, 780–789

Desforges JPW, Galbraith M, Ross PS (2015) Ingestion of Microplastics by Zooplankton in the Northeast Pacific Ocean. Archives of Environmental Contamination and Toxicology 69(3) 320–330

Frias JPGL, Otero V, Sobral P (2014) Evidence of microplastics in samples of zooplankton from Portuguese coastal waters. Marine Environmental Research 95:89–95.

GESAMP, 2015. In: Kershaw, P.J. (Ed.), Sources, Fate and Effects of Microplastics in the Marine Environment: a Global Assessment (Rep. Stud. GESAMP No. 90), p. 96(IMO/FAO/UNESCO_IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection)

Ivar do Sul JAI, Costa MF (2014) The present and future of microplastic pollution in the marine environment. Environmental Pollution. 185: 352–364

Jambeck JR, Geyer R, Wilcox C, Siegler TR, Perryman M, Andrady A, Narayan R, Law KL (2015) Plastic waste inputs from land into the ocean. Science 347: 768–771

Jang M, Shim WJ, Han GM, Song YK, Hong SH (2018) Formation of microplastics by polychaetes (*Marphysa sanguinea*) inhabiting expanded polystyrene marine debris. Marine Pollution Bulletin 131: 365–369

Kosore C, Ojwang L, Maghanga J, Kamau J, Kimeli A, Omukoto J, Ngisiag’e N, Mwaluma J, Ong’ada H, Magori C, Ndirui E (2018) Occurrence and ingestion of microplastics by zooplankton in Kenya’s marine environment: first documented evidence. African Journal of Marine Science 40(3): 225–234

Kvale K, Prowe AEF, Oschlies A (2021) Zooplankton grazing of microplastic can accelerate global. Nature Communications 12:2358

Lebreton L, Andrady A (2019) Future scenarios of global plastic waste generation and disposal. Palgrave Commun 5:6

Li J, Qu X, Su L, Zhang W, Yang D, Kolandhasamy P, Li D, Shi H, (2016) Microplastics in mussels along the coastal waters of China. Environmental Pollution 214: 177–184

Li J, Yang D, Li L, Jabeen K, Shi H (2015) Microplastics in commercial bivalves from China. Environmental Pollution 207: 190–195

Liu T, Zhao Y, Zhu M, Liang J, Zheng S, Sun X, 2020. Seasonal variation of micro- and meso-plastics in the seawater of Jiaozhou Bay, the Yellow Sea. Mar. Pollut. Bull. 152: 110922.

Lönnstedt OM, Eklöv P (2016) Environmentally relevant concentrations of microplastic particles influence larval fish ecology. Science 352(6290): 1213-1216.

Lusher AL, O'Donnell C, Officer R, O'Connor I (2016) Microplastic interactions with North Atlantic mesopelagic fish. ICES Journal of Marine Science 73: 1214–-1225

Md Amin R, Sohaimi ES, Anuar ST, Bachok Z (2020) Microplastic ingestion by zooplankton in Terengganu coastal waters, southern South China Sea. Marine Pollution Bulletin, 150: 110616

Murray F, Cowie PR (2011) Plastic contamination in the decapod crustacean Nephropsnorvegicus (Linnaeus, 1758). Marine Pollution Bulletin. 62: 1207–1217

Napper IE, Thompson RC, 2016. Release of synthetic microplastic plastic fibres from domestic washing machines: effects of fabric type and washing conditions. Mar. Pollut. Bull. 112: 39e45.

Park CH, Kang YK, Im SS (2004) Biodegradability of cellulose fabrics. J. Appl. Polym. Sci. 94 (1): 248–253

Plastics Europe (2017) Plastics – The Facts 2021. Plastics Europe, Brussels. https://plasticseurope.org/knowledge-hub/plastics-the-facts-2021/

Qiu Q, Peng J, Yu X, Chen F, Wang J, Dong F (2015) Occurrence of microplastics in the coastal marine environment: first observation on sediment of China. Mar. Pollut. Bull. 98 (1–2): 274–280

Rochman CM, Hoh E, Kurobe T, Teh SJ (2013) Ingested plastic transfers hazardouschemicals to fish and induces hepatic stress. Scientific Reports. 3: 3263

Setälä O, Fleming-Lehtinen V, Lehtiniemi M (2014) Ingestion and transfer of microplastics in the planktonic food web. Environmental Pollution 185: 77–83

Sun X, Li Q, Zhu M, Liang J, Zheng S, Zhao Y, (2017) Ingestion of microplastics by natural zooplankton groups in the northern South China Sea. Marine Pollution Bulletin, 115(1): 217-224

Thompson RC (2015) Microplastics in the marine environment: sources, consequences and solutions. In: Marine Anthropogenic Litter. Springer International Publishing, pp. 185e200

Van Cauwenberghe L, Janssen CR (2014) Microplastics in bivalves cultured for human Consumption. Environmental Pollution 193: 65–70

Wright SL, Rowe D, Thompson RC, Galloway TS (2013) Microplastic ingestion decreases energy reserves in marine worms. Current Biology 23: 1031–1033

Yu SP, Cole M, Chan BKK (2021) Review: effects of microplastic on zooplankton survival and sublethal responses In: Hawkins SJ, Allcock AL, Bates AE, Firth LB, Smith IP, Swearer SE, Evans AJ, Todd PA, Russell BD, McQuaid CD (eds) Oceanography and Marine Biology: An annual review, vol 58 pp 351

Zhao S, Zhu L, Li D (2016) Microscopic anthropogenic litter in terrestrial birds from Shangai, China: not only plastics but also natural fibers. Science of the Total Environment 550: 1110–1115

Zheng S, Zhao Y, Liangwei W, Liang J, Liu T, Zhu M, Li Q, Sun X (2020)

Characteristics of microplastics ingested by zooplankton from the Bohai Sea, China. Science of the Total Environment 713: 136357