ORIGINAL PAPER

Abundance of microplastics in some zooplankton groups at Hat Pak Meng, Trang Province, the Andaman Sea

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Abstract. Plastic debris, especially microplastics have become a concern in marine environmental studies worldwide. Marine organisms can ingest microplastics and transfer them along with the food web. Zooplankton comprises producers and primary consumers, including the larval phase of many economically important species that play critical roles in the marine food chain. Therefore, this study aimed to identify the characteristics and abundance of microplastics ingested by three zooplankton groups. Samples were collected at Hat Pak Meng, Trang Province, then preserved in 10% buffered formalin. The calanoid copepods, chaetognaths, and shrimp larvae were separated and then treated with H2O2 until completely digested. The microplastics particles were characterized by using µFT-IR. Our results revealed that the highest abundance of microplastics was found in shrimp larvae (0.70±0.10 particles/individual). The calanoid copepod showed highest abundance of microplastics per collection area (462.71±50.42 particles/m3), much higher than previous reports in that area about microplastics abundance per m^3 of seawater. The size of microplastics ingested had a positive correlation with the size of zooplankton. The characterization of microplastics by using µ-FT-IR revealed the presence of polyethylene terephthalate (PET), polyurethane foam, and rayon. PET and rayon showed high abundance in many places because they were used for clothing, beverage container, and food packaging. Our results revealed that the microplastics accumulated in the zooplankton might be potentially transferred through the marine food chain. Hat Pak Meng is occupied by human settlements a popular tourism destination. Therefore, measures to reduce the microplastics contamination on its coastal ecosystems are urgently required.

Keywords: PET, µFT-IR, microplastics, calanoid copepods, shrimp larvae

1. Introduction

Microplastics pose potential threats to the planktonic realm, endangering this important source of the world's biomass. With continuous growth for over 50 years, global plastic production rose to 335 million tons in 2016 (PlasticsEurope 2017). The occurrence and accumulation of marine debris in marine and coastal ecosystems have become a growing global concern in the last decade (Moore 2008), as it has been estimated that annually 6 to 10% of the global plastic production ends up in the marine environment; without improvement in waste management and infrastructure, the plastic waste will vastly increase by 2025 (Jambeck et al. 2015). The term microplastics refers to all items of plastic smaller than 5.0 mm in size (Arthur et al. 2009; Law and Thompson 2014; Thompson et al. 2004) and may be classified as primary or secondary, depending on the origin. Primary microplastics are manufactured pellets or granules used often as raw material in plastic industries, whereas secondary microplastics include fragments and fibers resulting from the photochemical degradation or mechanical abrasion of larger plastic items (Cole et al. 2011; Eerkes-Medrano et al. 2015).

Microplastics can affect marine organisms by blocking their alimentary tract upon ingestion and/or by toxic pollutants contained or absorbed by the plastics, and later infecting those organisms (Cole et al. 2015; Moore et al. 2005). The abundance of microplastics in the marine biome are ingested by all kinds of marine organisms including commercially important species of fish, shellfish and invertebrates (Thompson 2015; GESAMP 2015; Lusher et al. 2017). Therefore, microplastics are considered emerging pollutants and a threat to marine ecosystems (Avio et al. 2016).

Some studies have reported that a variety of invertebrates ingest microplastics, including various zooplankton groups such as copepods, jellyfish, chaetognaths and fish larvae (Cole et al. 2013; Murray and Cowie 2011; Sun et al. 2017). However, scientific data on the ingestion of microplastics by zooplankton populations and their possible accumulation in Thailand are limited. Therefore, this study aims to investigate the characteristics and abundance of microplastics ingested by three groups of zooplankton, i.e., calanoid copepods, chaetognaths, and shrimp larvae in a popular touristic beach and the Andaman Sea coast of Thailand

2. Materials and Methods

2.1 study site and samples collection

This study was carried out at Hat Pak Meng, Trang Province, the Andaman Sea (Figure 1.), in January 2018. The zooplankton samples were collected by 50 m of horizontal tows using a standard 120 µm mesh plankton net with a mouth diameter of 30 cm. Three zooplankton groups were collected and recorded from the analysis of the samples under stereomicroscope. The 50 individuals of each zooplankton group were assessed abundance and types of microplastics.

2.2 Microplastics Isolation

The zooplankton samples were cleaned with distilled water, treated with 30% hydrogen peroxide (H2O2) and heated up to 55-65 ºC until they were completely digested. Microplastics particles were separated from the digested samples by flotation in saturated sodium chloride solution (250 g/ml) (Mathalon and Hill 2014). After 24 h of floatation at room temperature, the overlying water was vacuum filtered through a 20 µm pore size filter. Several blanks, containing only H2O2 in an empty vial, were run to correct for potential air-borne particle deposition in the laboratory. No contamination of blanks was observed during the experiments. Each filter was placed into a clean glass petri dish for observation under a stereoscopic microscope and photographed with a digital camera.

2.3 Microplastics Identification and Qualification

All plastic particles were visually identified, counted and measured, by classifying them according to four size classes: 100–500 µm; 501–1000 µm; 1001–1500 µm and 1501-2000 µm. The micro Fourier Transform Interferometer (µ-FT-IR, Model: Frontier, PerkinElmer) was used to identify the type of microplastics samples contained in zooplankton by comparing with standard spectrums of microplastics.

2.3 Data Analysis

One-way ANOVA with Tukey HSD test was used to analyze the difference of microplastics abundance among zooplankton groups in R program version 3.3.2 package "vegan". R program package "vegan" was used to perform spearman's correlation between the size of zooplankton and the size of microplastics.

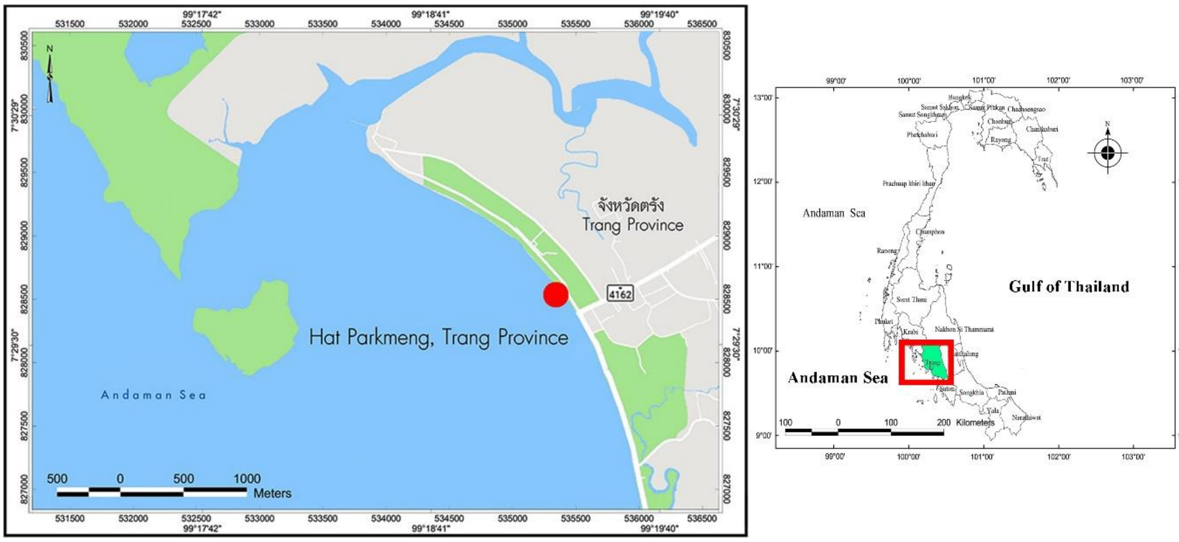

Figure 1. location of sampling site, Hat Pak Meng, Trang Province

3. Results

The abundance of microplastics significantly varied across zooplankton groups, and the highest abundance of microplastics was found in shrimp larvae, followed by chaetognaths and calanoid copepods. The length of the microplastic particles ranged from 201 µm to 2000 µm. In addition, densities of shrimp larvae, chaetognaths, and calanoid copepods from zooplankton samples at Hat Pak Meng were also significantly different (p=0.05) (Table 1). The accumulation of microplastic per individual was also significant (Figure 2.). In this study, all microplastics were ingested by zooplankton groups that were fibrous.

The highest proportion of microplastics ranged from 501-1000 µm in size, especially in shrimp larvae and chaetognaths, while the highest composition accumulated in calanoid copepods ranged from 100-500 µm. The microplastics accumulated in calanoid copepods were smaller than in chaetognath and shrimp larvae (Figure 3.)

The spectrum of microplastics collected was concordant with the spectrums of polyethylene terephthalate (PET), polyurethane foam, and rayon (Figure 4.), indicating that those were the main components of the fibrous microplastics here sampled.

The zooplankton sizes of each group were positively correlated with microplastics sizes found. The Shimp larvae size was exhibited highest correlation (r= 1), follow by calanoid copepod (r= 0.79) and chaetognaths (r= 0.61), respectively (Figure 5.).
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Table.1 Density and sizes of zooplankton and microplastics sizes

Zooplankton group	Density of zooplankton (individual/m^3)	Size of zooplankton (mm)	Size of microplastics (µm)
Calanoid copepods	4620.85±357.92^{a}	1.04±0.08^{b}	660.59±205.91^{a}
Chaetognaths	1247.36±105.62^{b}	2.76±0.30^{a}	1060.08±233.24^{a}
Shrimp larvae	180.23±34.12^{c}	2.84±0.53^{a}	1020.75±312.41^{a}

Values are expressed as mean ± standard deviation (n=50)
$^{a-c}$ value in the same row with a different superscript letter is significantly different (*p* <0.05) between the mean values.

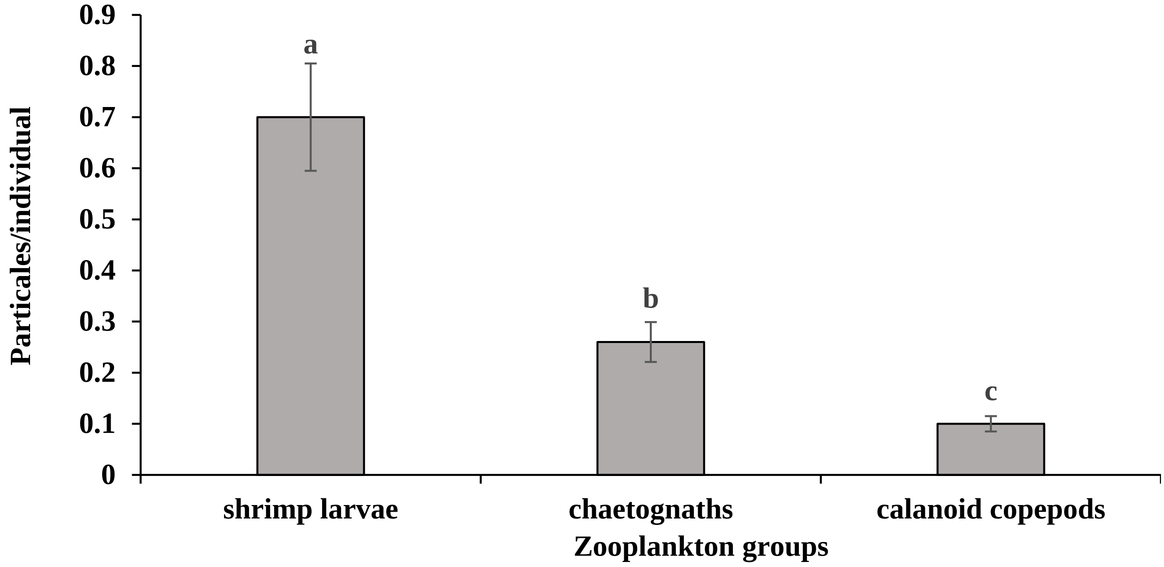


Figure 2. The abundance of microplastics ingested by three zooplankton groups

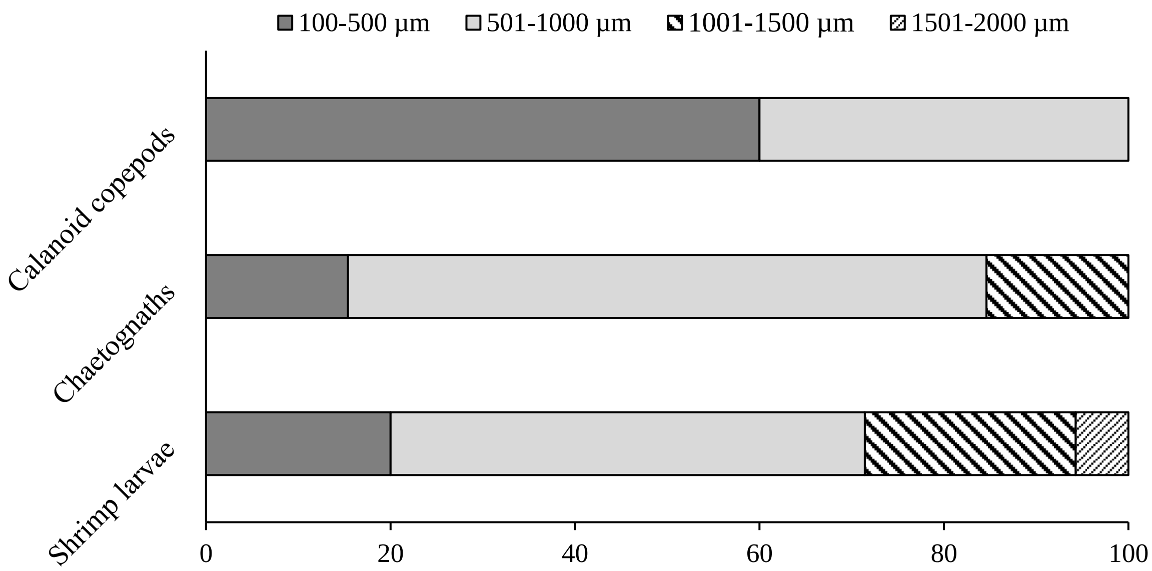
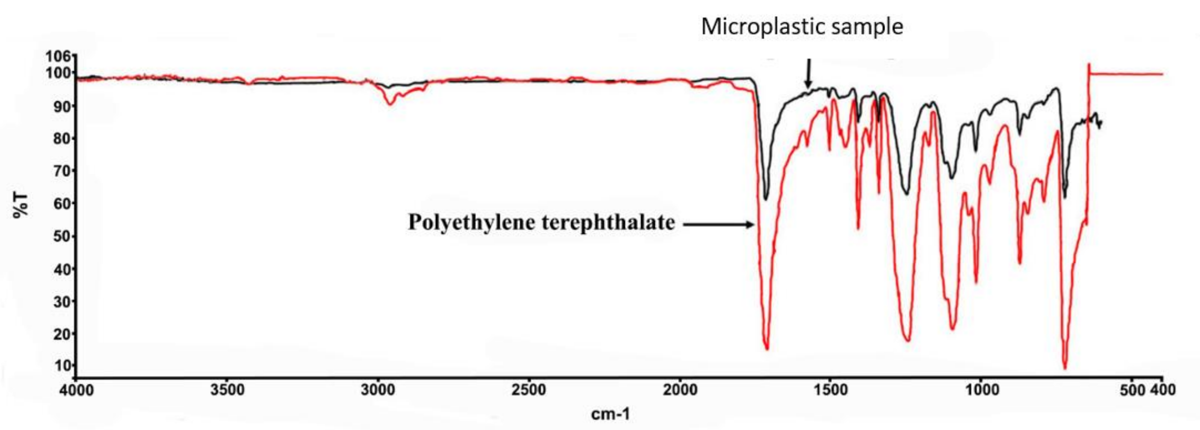


Figure 3. The abundance of microplastics ingested by three zooplankton groups



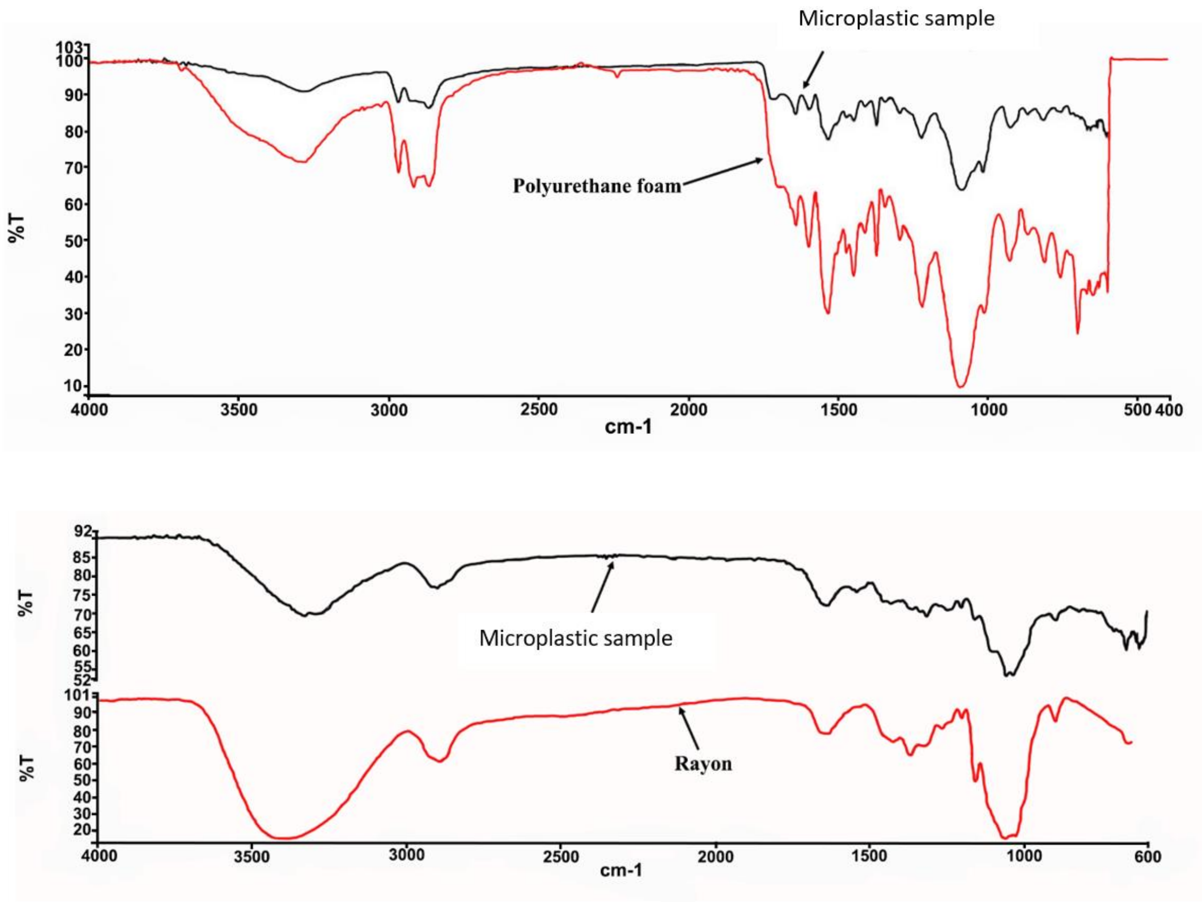


Figure 4. The μ-FT-IR spectrum of microplastics sampled

4. Discussion

The consequences of ingested microplastics effects on zooplankton health are still uncertain. Zooplankton plays an essential role in marine ecosystems, as primary consumers in the marine food web transferring energy to higher levels, in addition, survival of larval stages is important to the maintenance of marine populations and fishing stocks. Small plastic litter is currently widely spread in the water column, facilitating interactions between zooplankton and microplastics (Moore et al. 2001; Moore et al. 2002; Collignon et al. 2012). Our results showed that the lowest abundance of ingested microplastics per individual was found in calanoid copepods which feed on phytoplankton, while the highest densities were observed in shrimp larvae which are carnivores or omnivores that indiscriminately feed on floating food items, thus ingesting more plastics than the other groups, in addition to being unable to eliminate those particles from their organisms (Desforges et al. 2015). Moreover, the average size of ingested microplastic particles in shrimp larvae was greater than calanoid copepods although lacking significant difference (Table 1). The size of microplastic in chaetognaths was similar to those in shrimp larvae that might result from the similar size between both groups. In addition, the size of zooplankton was positively correlated with the size of microplastics, shrimp larvae ($r = 1.00$), calanoid copepods ($r = 0.79$) and chaetognaths ($r = 0.61$). The accumulation of microplastics in zooplankton that varying between species, life-stage, and microplastic size (Cole et al. 2013; Setälä et al. 2014).

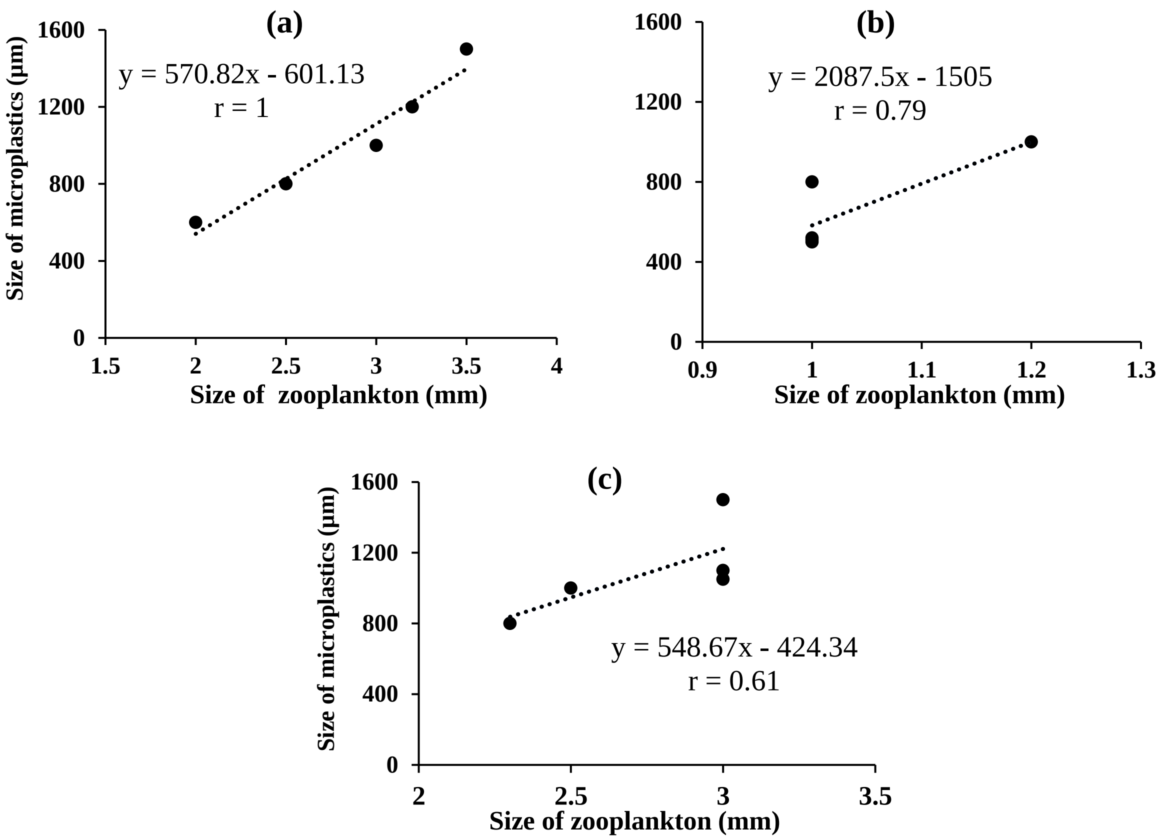


Figure 5. Spearman correlation between size of microplastics and size of zooplankton (a) shrimp larvae, (b) calanoid copepod and (c) chaetognaths

The microplastics accumulation of different zooplankton groups from Hat Pak Meng was relatively high when compared to other regions such as the northern South China Sea, China (Sun et al. 2017) however, low when compared with a study in Himmerfjärden Bay, Sweden (Gorokhova 2015). A previous study showed that the average abundance of microplastics in seawater from Hat Pak Meng in January 2018 was 27.7 particles/m3 (Rongprakhon et al. 2018). Therefore, the abundance of microplastics in shrimp larvae, chaetognaths and calanoid copepods was much higher than free microplastics in seawater 5:1, 12:1 and 17:1 ratio, respectively.

Particles of PET and rayon were the most abundant microplastics at Hat Pak Meng: rayon are man-made fiber usually used for clothing, whereas PET is one of plastics in daily life that used for beverage container, food packaging (flexible PET), and clothing as well (Maeda et al. 2015; Vigneswaran et al. 2014). The abundance of PET and rayon might result from the degradation of larger debris that ends up in the sea due to human settlements and tourism activities at Hat Pak Meng, which is the most developed beach in Trang Province. Ingestion of PET and rayon are have been reported for fish (Lusher et al. 2013; Compa et al. 2018), which can be accumulated by direct ingestion or by their zooplankton prey (Ory et al. 2017). Our results rise concerns on the high abundance of microplastics ingested by three common zooplankton groups. Further work should study other marine organisms, in order to understand how microplastics are transferred along with the food web.

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