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Microplastics in marine sediment at the coral reef hotspots of Mu Ko Similan National Park, Phang Nga Province

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Abstract. An increased global plastic production with improper management of plastic waste leads to serious environmental problems. Microplastics have been recognized as a major threat to marine ecosystems, which can be spread through the environment. This study aims to investigate the accumulation of microplastics in marine sediment collected from seven coral reef hotspots at Mu Koh Similan National Park, Phang Nga Province, i.e., Hat Lek (Koh Si), Ao Khon Kae, Ao Fai Waeb, East of Eden, Hin Muan Diao, Ao Nam Chai, and West of Eden. The results showed that the highest accumulation of microplastics was found at Hat Lek (Koh Si) with a density of 595 pieces/Kg dry weight. Conversely, the lowest density of the microplastics was found at East of Eden (219 pieces/Kg dry weight). The size of microplastics ranged between 500-1,000 µm for most particles. This study suggests the necessity of guidelines to reduce microplastics pollution in order to support the sustainability of marine ecosystems.

Keywords: microplastics, coral reefs, Mu Ko Similan, Thailand, marine sediment

1. Introduction

Global plastic production has been continuously growing for over 50 years, reaching 348 million tonnes in 2017 (Plastics Europe 2018). The increased accumulation of plastic debris in marine ecosystems has become a global concern over the last decades (Moore 2008). It has been estimated that 6 to 10% of global plastic production ends up in the marine environment annually due to improper waste management systems. In Thailand, it was estimated that approximately 150,000-410,000 metric tons of land-based plastic waste flows into the ocean annually, expecting to be vastly increased by 2025 (Jambeck et al. 2015).

Currently, microplastics are classified as all items of plastics that are smaller than 5.0 mm, and have been recognized as an important waste due to their high abundance in seawater and accumulation in the marine food web. Microplastics can be ingested by a wide range of marine organisms, for example, fishes, marine mammals, other commercially important species, and have several negative effects to those animals such as blocking their digestive system, causing intoxication by persistent organic pollutants (POPs) contamination etc. (Moore et al. 2005; Arthur et al. 2009; Law and Thompson 2014; Cole et al. 2015; GESAMP 2015; Thompson 2015; Avio et al., 2016; Lusher et al. 2017).

Microplastics have been found in various marine ecosystems across the world, including seawater, deep-sea and coastal sediment. Sediment is an important part of coastal marine habitat, consisting of various types and sizes, ranging from gravel to fine muds, making it to be the world's largest habitat in terms of area coverage (Snelgrove 1997). Several studies show that microplastics are discovered in sediment from both coastal shallow (Claessens et al. 2011; Vianello et al. 2013) and the deep seas (Van Cauwenberghe et al. 2013). It has been hypothesized that microplastics sink and accumulate in sediments, posing an ecological risk to benthic communities (Bergmann et al. 2017).

Mu Ko Similan National Park is located in Phang Nga Province, which is a popular tourism destination on the Thai coasts of the Andaman Sea. During the tourism season, more than 7,000

tourists visit Mu Ko Similan daily, generating a large number of solid wastes. However, waste management facilities in this area are insufficient to cope with waste generated by tourists. Hence, some waste residues could potentially contribute to the accumulation of microplastics problems in this area. This study aims to evaluate the accumulation of microplastics in marine sediments at Mu Ko Similan, Phang Nga Province, Andaman Sea.

2. Materials and Methods

2.1 Sampling sites

The sampling sites were located at Hat Lek (Koh Si) (8°33'56.56 N, 100°49'14.65 E), Ao Khon Kae (8°29'10.27 N, 97°38'28.10 E), Ao Fai Waeb (8°38'15.87 N, 97°39' 12.36 E), East of Eden (8°35'23.16 N, 97° 38'31.33 E), Hin Muan Diao (8°34'13.43 N, 97°38' 51.00 E), Ao Nam Chai (8°40'33.81 N, 97°38'45.20 E) and West of Eden (8°35' 39.49 N, 97°38'19.76 E) in Mu Koh Similan National Park, Phang Nga Province.

2.2 Sample collections

Marine sediment samples were collected from coral reef areas using a round core with a 3.5 cm diameter and 10 cm height. The round core was inserted into the sediment of the seafloor and the depth ranged from 5-13 m from the surface. The samples were then preserved in 10% buffered formalin solution and transferred to the Marine Biodiversity Research Group laboratory, Ramkhamhaeng University.

2.3 Microplastics Isolation

The marine sediment samples were dissolved in filtrated seawater, then the solution was filtrated using a vacuum pump with a filter paper (Whatman No.3). Organic matter in the samples was digested with 1M NaOH at room temperature for 24 h, and heated up to 60 °C for two hours, then ramped to 100 °C for one hour. The microplastics were separated from the digested samples by flotation in saturated sodium chloride solution (250 g/L) for six hours then the sampled seawater was filtrated by vacuum pump with filter paper (1.2 µm pore size, GF/C), these methods were modified from Mathalon & Hill (2014) and Masura et al. (2015). The microplastics were detected by visual identification, counted and measured under the stereomicroscope. Fourier-transform infrared spectroscopy (FTIR) was also applied to detect the type of microplastics.

2.4 Data Analysis

Microplastics detected in the samples were categorized into four classes: 100-500 µm, 501-1000 µm, 1001-2000 µm, 2001-5000 µm. The accumulation of microplastics was expressed as particles/kg of dry sediment and the difference in the accumulation of microplastics in marine sediment among sampling sites was tested using one-way ANOVA with Tukey's HSD test. All statistical analyses were performed via R Program version 3.3.2

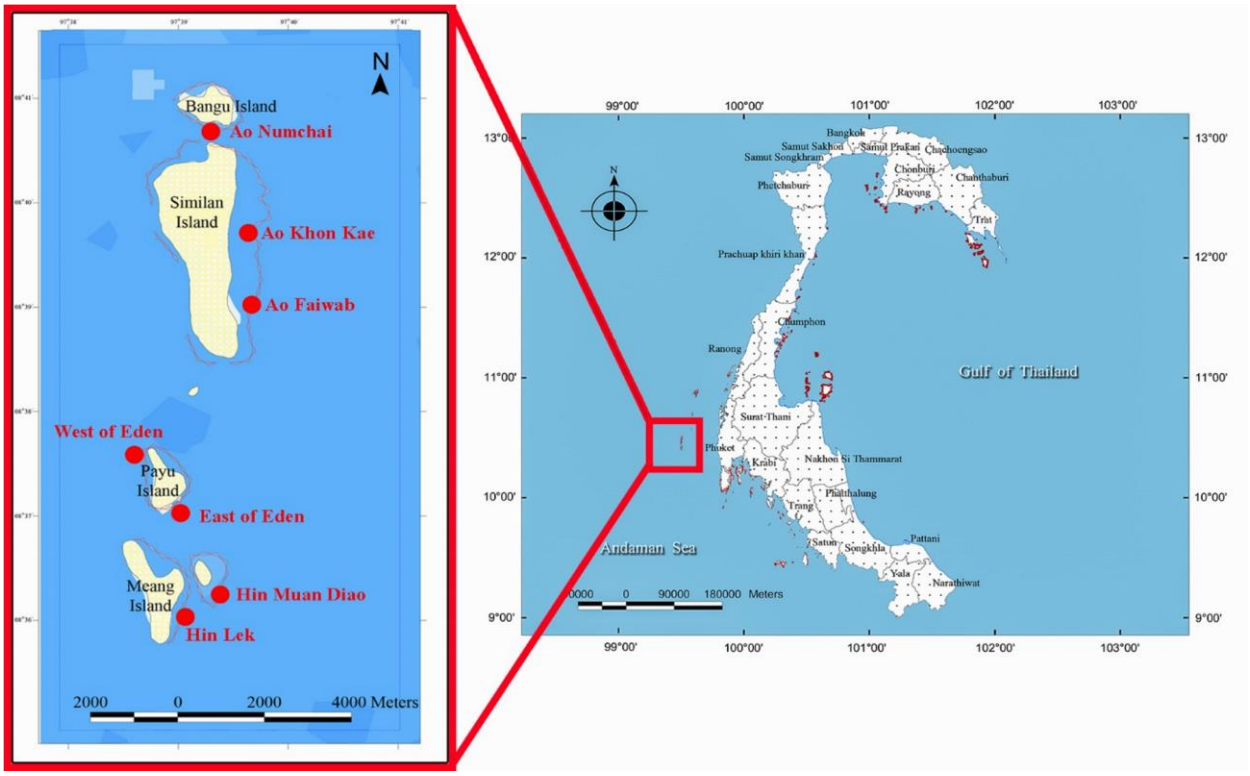

Figure 1. The sampling sites at Mu Ko Similan National Park, Phang Nga Province

3. Results

The highest accumulation of microplastics was found at Hat Lek (595 particles/Kg dry sediment), whereas the lowest one was detected at East of Eden (219 particles/Kg dry sediment) (Figure 2). The accumulation of microplastics found at Hat Lek was significantly different from other sampling stations ($p<0.01$). Except for Hat Lek, no significant difference was found among other sampling stations.

The microplastics particles found at Hat Lek, Ao Nam Chai, Ao Khon Kae, Hin Muan Diao and East of Eden, were mostly in the size class of 501 to 1000 µm. Microplastics particles at West of Eden and Ao Fai Waeb were mostly found in the size class of 1001 to 2000 µm and 2001 to 5000 µm, respectively (Figure 3). Microplastics particles with fibrous shapes were mainly detected, having different colors such as blue, black, red or green, colourless. Most microplastics particles were mostly blue and colourless (Figure 4).

The FT-IR spectra of the two most common types of microplastics are shown in Figure 5. The two different types of microplastics particles were encountered at all study sites. Polyethylene (PE) and Polypropylene (PP) were the most abundant polymer types, and these are major components in plastics production (Figure 5).

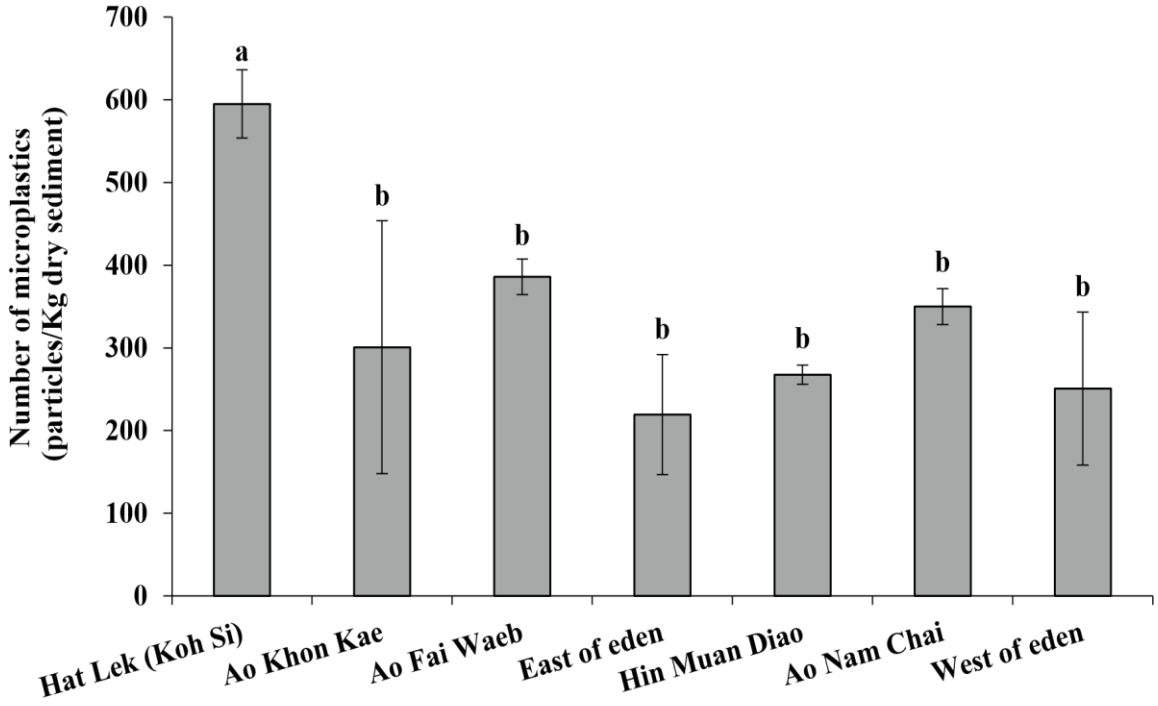

Figure 2. The accumulation of microplastics in marine sediment at each study site

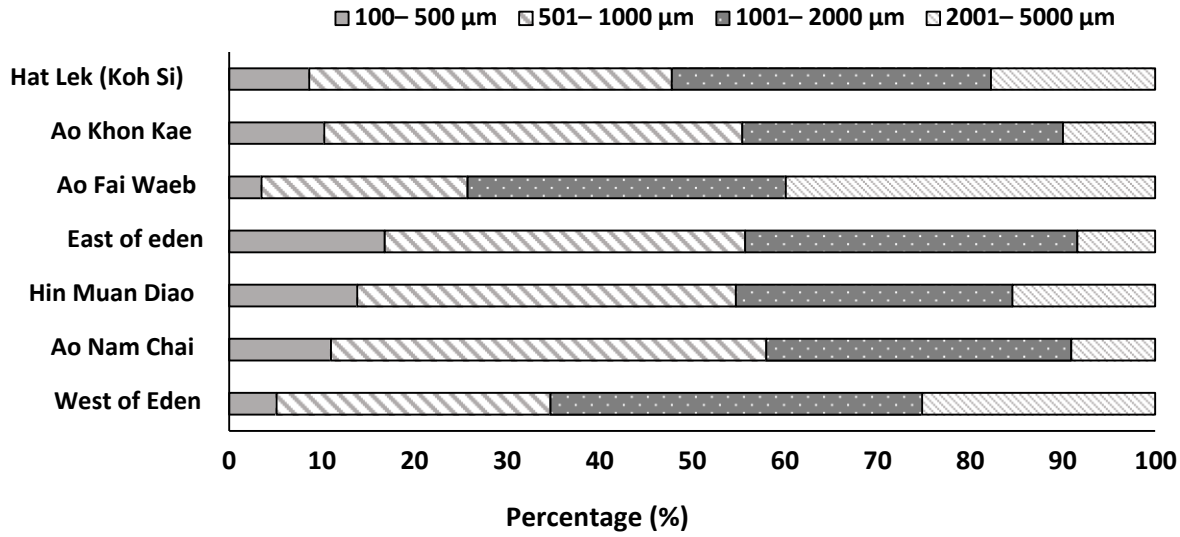

Figure 3. The distribution of microplastics among size classes in marine sediment at each study site

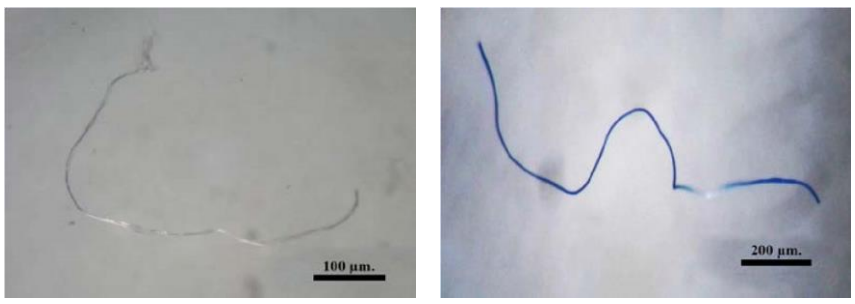

Figure 4. The example of microplastics isolated from marine sediment

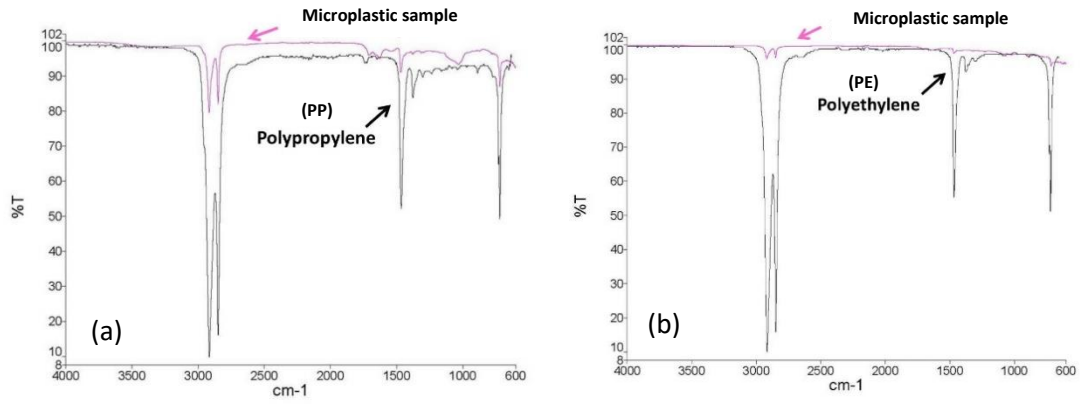

Figure 5. FT-IR spectra of microplastic samples; (a) polypropylene (PP), and (b) polyethylene (PE)

4. Discussion

The accumulation of microplastics in marine sediments has been widely reported in many locations across the world, such as the Belgian coast (Claessens et al. 2011), Hong Kong (Tsang et al. 2017), Antarctica (Reed et al. 2018), Mediterranean Sea (Abidli et al. 2018), northern Baltic Sea (Näkki et al. 2017) and the coast of China (Qiu et al. 2015; Wang et al. 2018; Zhao et al., 2015). The number of floating plastics is relatively low compared with the number of plastics discharged from rivers, indicating that there are many more missing sink plastics in the marine environment. Disparities in the size of microplastics floating at the sea surface also point to a missing sink. (Matsuguma 2017). When microplastics sink to the seafloor, the accumulation in sediments could possibly increase the chance of microplastics ingestion in benthic organisms, which may cause negative effects such as internal abrasions and blockages in the digestive system (Zhao et al. 2018; Clunies-Ross et al. 2016). Furthermore, marine fauna and infauna, a lower trophic organism, can ingest and accumulate microplastics, thus transferring and magnifying the amount of microplastics through the food web (Wright et al. 2013).

Our result showed the highest accumulation of microplastics at Hat Lek. This may be due to the mass tourism activities along the sandy beach. Improper waste management also causes the residues of solid waste, which can further contaminate the sea. The accumulation of microplastics in marine sediments in Thai coastal areas has already been reported by the study of Matsuguma et al. (2017), indicating that microplastics pollution has increased over time. Moreover, there is a positive correlation between an increase in plastic consumption in Thailand and the significant increase in the abundance of microplastics in marine sediment. The results from our study showed that, in marine sediment in Thai Waters, microplastics were higher than in other regions, for example, the Belgian coast where the total microplastics concentrations ranged between 48.7 - 390.7 particles/kg dry sediment (Claessens et al. 2011). In Hong Kong, the mean abundance of microplastics in sediment ranged from 49-279 particles/kg dry sediment (Tsang et al. 2017). In addition, concentrations of microplastics particles from the Mediterranean Sea varied from 141.2 - 461.3 particles/kg dry weight. (Abidli et al. 2018). However, the abundance of microplastics in marine sediment from this present study was lower than that observed in China, where a relatively large concentration of microplastics was reported of 250.7-435.7 particles/50g dry sediment (Qiu et al. 2015). The high abundance of microplastics along the coasts of Thailand might result from the high amount of plastic waste residues from the mainland discharged into the ocean.

Characteristics of microplastic such as colours, physical shape etc. could be useful for tracking its source. In this study, colourless and blue microplastic particles were most dominant in

the sediment. Fibrous microplastics in sediment were mainly detected in this research. The Belgian coast also had the highest concentration of microplastic fibres (Claessens et al. 2011). FT-IR spectra confirmed that the microplastics type in our research were polypropylene (PP) and polyethylene (PE), which were the main microplastics found in the marine sediment in all study sites. Polypropylene (PP) and polyethylene (PE) are the main components of fishing net and line, packaging of food and other products (Qiu et al. 2015). Moreover, Polypropylene fibres are used in manufacturing other products such as carpets and ropes, which are widely used on hotels and ships (Claessens et al. 2011).

This study highlights that microplastics pollution is an urgent problem of the marine ecosystem. The current level of microplastic contamination in Thailand's coastal areas reflects a significant issue to be concerned. Additionally, regulating authorities should pay more attention to the concern. Furthermore, there should be guidelines and regulations to reduce plastic consumption and effective waste collection and management to promote the sustainability of the marine ecosystem.

Acknowledgments

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