Preliminary Study of Abundance and Characteristics of Microplastics on Beach Sediment along the Coast of Rayong Province, Thailand

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Abstract. This study concentrates on the beach sediment collected at Suchada (SD), Saeng Chan (SC) and Laem Charoen (LM) beaches in the Rayong province of Eastern Thailand. The samples were collected for a preliminary investigation for microplastic contamination. A total of 18 samples were taken parallel with the shoreline at the depth of 5 centimetres. They were collected between the months of August to September 2019. Density separation, microscopic inspection and ATR-FTIR analysis were conducted to analyze the characteristics of microplastics and the type of polymers. The average concentration of microplastics on three beaches was 568.33 ± 153.05 items per kilogram of dry weight. Based on the categorization according to shape, colour, and size, microfibers accounted for a dominant proportion of microplastics. Blue (>45%) and 1,000-5,000 µm particle sizes were the most prevalent microplastics in SC and LM beaches, while red (43%) colour and small microplastics (100-500 µm) were the dominant proportion in SD beach. ATR-FTIR analysis determined that the polymers found in microplastic were polypropylene, polyethylene, low-density polyethylene and cellophane. These results indicated that land-based sources also those including tourism activities, fishery activities, river, and sewage discharge from industrial and urban communities are most likely the main source of microplastics in beach sediment along the coast of Rayong province.

1. Introduction
In recent years the enormous usage of plastic has alarmed human society with growing scientific evidence presented concerning the deleterious impacts of end-of-life plastic products on the environment and wildlife. Study shows that 4.8 million tons of plastic waste enters the oceans every year and the cumulative quantity of plastic waste that is available to enter the oceans from the land by 2025 is predicted to increase by an order of magnitude [1]. The dynamics of the oceans as well as anthropogenic factors can result in the crushing of plastic debris and the formation of microplastics. Recently, microplastic pollution in the oceans, which is causing growing concern, has been detected around global oceans, i.e. water column, nearshore sediment and offshore sediment. Hazardous microplastic polymers are known to induce detrimental biological effects on marine organisms, including intestinal blockage, tissue abrasion, interference with metabolism and so on [2, 3].

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The widespread occurrence of microplastics in various marine environments is well documented. However, in Thailand, the abundance of microplastics in sediments have only been reported in Phuket Province, in the South of Thailand [4]. By contrast, the pollution levels and characteristics of microplastics in coastal areas of Eastern Thailand are rarely reported. Rayong is a coastal province located in the east coast of the Gulf of Thailand and is well known as an industrial hub of Thailand. Due to rapid economic growth, Rayong faces great pressure from human activities, for example, Rayong is becoming a centre for the chemical and automobile industries, maritime shipping, fishing, as well as tourism activity, which puts a certain degree of pressure on the ecological security of the shoreline area. The vast majority of plastic debris is produced onshore and reaches the coastal environments as the main sink for plastic debris. An understanding of the extent of microplastic pollution in coastal environments will be essential as a basis for environmental impact assessment and development of sustainable management plans for marine waste. Data on sources, distribution and composition of microplastic debris is crucial in order to assess and predict the toxicity of plastic waste in coastal environments, while also determining the depositional behaviour of microplastics within sediments. Therefore, the objectives of this study were 1) to investigate the abundance and characteristics of microplastics in the coastal areas at Rayong Province, and 2) to examine the relationship between the occurrence of microplastic and accelerated human activity in coastal areas.

2. Materials and methods

2.1. Study area

Three sampling locations were chosen because (Suchada Beach; SD, Saeng Chan Beach; SC, and Laem Charoen Beach; LM), the coastal region is one of the most densely urbanized industrial zones in Rayong Province, to represent three different beaches with different anthropogenic activities (figure 1 and table 1).

![Figure 1](image-url)  
**Figure 1.** Sampling location for the microplastics along the coast of Rayong Province, Thailand.

2.2 Sampling

The sampling was done at the high tideline on three beaches between the months of August to September 2019. Each beach can be divided into three sampling stations along the shoreline, i.e. top, middle and bottom sampling stations. Two replicated samples were collected in each sampling station, with 6 samples per beach. A gap of approximately 30 m was maintained between three sampling
replicates. The upper 5 cm of the sediment was removed with a clean stainless-steel spoon, transferred to an aluminium tray and immediately covered with new clean aluminium foil. Subsequently, the 18 samples were carried to the laboratory and refrigerated at a temperature of 4 °C prior to the analysis.

**Table 1. Location and description of the studied areas.**

| Location                  | Station | GPS coordinates          | Description of the studied areas                      |
|---------------------------|---------|--------------------------|-------------------------------------------------------|
| Suchada Beach (SD)        | S1      | 12°40'07.9"N 101°10'51.1"E | Coastal fishery village, seafood restaurants and close to the industries |
|                           | S2      | 12°40'10.5"N 101°11'38.8"E |                                                        |
|                           | S3      | 12°40'07.7"N 101°12'02.6"E |                                                        |
| Saeng Chan Beach (SC)     | S4      | 12°40'02.8"N 101°13'17.8"E | An area of a high density of seafood restaurants and hotels |
|                           | S5      | 12°40'02.8"N 101°12'57.9"E |                                                        |
|                           | S6      | 12°39'41.1"N 101°15'11.7"E |                                                        |
| Laem Charoen Beach (LM)   | S7      | 12°39'31.2"N 101°15'57.4"E | Seafood restaurants close to Rayong estuary           |
|                           | S8      | 12°39'27.4"N 101°16'11.5"E |                                                        |
|                           | S9      | 12°39'20.2"N 101°16'31.2"E |                                                        |

**2.3 Sample analysis**

A density separation method was carried out in accordance with the U.S. National Oceanic and Atmospheric Administration (NOAA) to isolate microplastics from sediment with slight adaptation [5]. The bulk samples were briefly dried in the oven at 70 °C for a period of 24 h. A 50 g dried sediment samples were then separated from the bulk and sieved through 5 mm mesh to separate the microplastics. Following, the samples were transferred into a clean glass beaker. Approximately 37 mL of H₂O₂ (30%) and 350 mL of deionized water was added to the samples to digest the natural organic matter (e.g. diatoms), then the mixture was stirred at a temperature of 75 °C for 3 h. To achieve density separation, NaCl was dissolved in the mixture to prepare a concentrated solution with 5 mol/L and manually stirred with a clean glass rod for 5 min. The mixture was covered with aluminium foil and allowed to stand for 24 h. After 24 hours of sedimentation, the supernatant was then filtered over 1.2 µm glass fibre filter paper (Whatman GF/C) under vacuum filtration to retain the microplastics. Finally, filter membranes were collected in sealed petri dishes and air-dried for a period of 24 h for further quantitative and qualitative analysis.

**2.4 Microscopic inspection**

The microplastic particles on the filters were optically analyzed and photographed using a microscope with 100x magnification to locate possible microplastics. A visual assessment was then performed to identify the shape, colour, and size of microplastics according to the physical characteristics of the particles. Particle shape was categorized into three groups: fibres (fibrous plastic strands), fragments (hard, jagged-edged particles), and micro-pellets (hard, rounded particles). Particle colour was divided into six categories: transparent, white, blue/green, grey/black, yellow/orange/brown, pink/red. Mesoplastic particles larger than 5000 µm were not included in these results. Particle in size range of < 100 µm, 100-500 µm, 500-1,000 µm, and 1,000-5,000 µm were analyzed.

**2.5 Microplastic identification**

Attenuated Total Reflectance-Fourier transform infrared spectroscopy (ATR-FTIR) was applied to identify polymer types of suspected microplastics. Library comparison results that match > 70% confidence can be concluded to be plastic polymer.

**2.6 Data analysis**

Equal mass of sediments (50 g) was always analyzed. The number of microplastic particles found in the eighteen replicates from each location were averaged and presented as mean ± standard deviation (SD) of microplastic particles. The features of the collected microplastic particles, comprising of colour, shape, and size, were expressed as relative abundance (%). The distribution of features of the
microplastic particles was expressed as mass concentration by normalized for 1 kg of dried-weight sediment sample (number of items/kg d.w.). Moreover, one-way analysis of variance (ANOVA) was conducted at 95% confidence level ($p=0.05$) in order to establish the variability in microplastics abundance (in mass concentration) in beach sediment between the three locations.

3. Results and discussion

3.1. Microplastic abundance
Microplastics were detected in all of the 18 sediment samples from SD, SC, and LM beaches, indicating the widespread distribution of microplastics in Rayong’s beaches. No microplastics were found on the blank control. In total, 805 microplastics were separated, with the abundances ranging from 423.33 to 728.33 items per 1 kg of dry weight sediment (i.e., d.w.) and an average abundance for the three beaches of $568.33 \pm 153.05$ items/kg d.w. The distribution of microplastics in sediment samples for the three beaches is presented in figure 2a. The highest concentration of microplastics was found in SD beach samples with an average abundance range of $728.33 \pm 312.56$ items/kg d.w., which was significantly higher than those from the other sites ($p < 0.05$). Meanwhile, the mean abundance of the SC and LM samples was $553.33 \pm 96.06$, and $423.33 \pm 256.88$ items/kg d.w., respectively. Examples of different types of microplastics collected from the three locations are illustrated in figure 2b.

Previous studies have indicated that land input presents a significant source of microplastics to the marine [6, 7]. Although SD area is closed to the industrial zone, river, and fishery and urban community, microplastics in the SD area were distributed by the industrial water, riverine input, and marine activities. This might lead to a higher regional microplastic contamination level. Meanwhile, the SC beach is in the centre of shoreline with high intensity of tourist activity, i.e. a high number of seafood restaurants and hotels, that are heavily visited by both tourists and local people. Therefore, tourism activities represent the main source of microplastics pollution. Moreover, the LM area is located near the Rayong River estuary and urban community, thus the vast amount of sanitary sewage along with tourism activities are the main sources of the microplastics for the area.

![Figure 2](image_url)

**Figure 2.** a) The average abundance of microplastics in SD, SC, and LM beaches (error bars indicate standard error of the mean); and b) different shapes of microplastics in beach sediments collected from the three locations. A) Fibre, B) and C) fragments, and D) pellet.

3.2. Microplastic shape, colour, and size
Different shape, colour and size of microplastics collected from the selected sampling locations are presented in figure 3. As illustrated in figure 3a, fibre was the most dominant component across all sample while the shape, accounting for more than 50%; followed by fragments and pellets. The shape
of a great majority of microplastics in LM beach was fibre (> 92%), which coincided with the highest intensity of urban community. The earlier study suggested that a large proportion of microplastic fibres found in the marine environment may originate from sewage, as a consequence of washing clothes which are made from synthetic materials such as polyester or nylon [8, 9].

Due to different pollutant sources and environmental processes (e.g. erosion, solar radiation, biodegradation), microplastics detected in the coastal environment have regular and irregular shapes. The regular shapes typically come from a direct release (primary microplastics), which include pellets, beads, or spherules; while the irregular shapes mainly arise from degradation of larger plastic debris (secondary microplastics), which contain fibres, fragments, and other irregular shapes [10]. Accordingly, our results show that no virgin pellets observed in the sediment of SC, while only small amount of pellets were observed in LM (figure 3a), indicating that microplastics in SC and LM were mainly secondary microplastics formed by fragmentation of larger plastic debris. In contrast to the SD, it seems to have been due to the SD area being closed to the industrial practices, thus leading to the higher regional microplastic contamination levels of primary microplastics.

![Figure 3](image)

*Figure 3.* Microplastic abundance in beach sediment collected from the SD, SC, and LM beaches by a) shape, b) colour, and c) size.

In regards to the particle colours (figure 3b), > 72% of total microplastics were multicolour; transparent and white accounted for between 14 to 27% of the total. However, this differs between the three sites. Blue microplastic particles were relatively abundant in SC and LM. However, in contrast by SD area, red and yellow colours were predominant, followed by blue and white. These results indicate that the colours of microplastics were related to their sources. Peng et al. (2017) reported that
the main source of multicolour microplastics found in sediment is caused by laundering clothes [11]. Similar results have been observed in beach sediments collected from Phuket Province, Thailand [4]. Furthermore, microplastics were classified into four categories (<100 µm, 100-500 µm, 500-1,000 µm, and 1,000-5,000 µm) based on their size, and their relative proportions in different sampling locations and are presented in figure 3c. Large microplastic particles (1,000-5,000 µm) were observed in SC (44.23%) and LM (48%) beaches, while the percentage of the other two size classes; i.e. 100-500 µm and 500-1,000 µm ranged from 16% to 25%. >50% of the microplastics in the beach of Fernando de Noronha fell into the size range between 1,000 to 5,000 µm [12], which were close to our results. A different source, polymer types, and environmental factors may explain the varied distribution of microplastics in different study areas. By contrary, the majority of microplastics (100-500 µm) were in the most abundance found on SD beach and accounted for 67.37%, followed by 500-1,000 µm, which occupied 19.08%. The small-sized microplastics (< 1,000 µm) has been demonstrated in many studies [11, 13]. The numerous small-sized particles detected suggested that microplastics were probably from effluent, not only from the decomposition of larger plastic debris into small particles [14].

3.3. Identification of microplastics using Attenuated Total Reflectance-Fourier transform infrared spectroscopy (ATR-FTIR)

As shown in figure 4, 4 types of polymer were identified: polypropylene (PP), polyethylene (PE), PE low density, and cellophane, with a matching degree > 91%. Among the identified microplastics, PP and PE were the most abundant polymer type. Similar results have been reported by Hidalgo-Ruz et.al and Vianello et al. [15, 16]. They found that PE and PP are the most common polymer types of microplastics in coastal environments. The apparent reason for high abundance of PP and PE in beach sediment could be their higher consumption rate, as well as their low density, which make them push to beaches from oceans [17]. Furthermore, cellophane is an organic cellulose-based polymer used wildly in food packaging [18].

![Figure 4. The FTIR spectrum of selected microplastics and the matching degree with the standard spectrum.](image)

4. Conclusions

In summary, microplastics were widespread in surface sediments collected from the shoreline of Rayong Province, Thailand. The average microplastics abundance was 568.33 ± 153.05 items/kg d.w. Fiber was the most abundance shape. Main colours of the collected microplastics were blue, red and yellow. Microplastic 100-500 µm account for more than half of the total microplastic in SD, while particles of 1000-5000 µm were predominant in both SC and LM beaches. Based on ATR-FTIR analysis, the majority of detected microplastics were PP and PE. Our study speculates that land-based sources also those including tourism activities (hotels and beach restaurants), fishery activities, river,
and sewage discharge from industrial and urban communities are most likely the main source of microplastics in beach sediment along the coast of Rayong Province. The findings could also support future studies on the modelling of microplastics mitigation ranging from coastal areas to remote marine environments, as well as the evaluation of the environmental risks posed by microplastics.

5. References

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