Status of Microplastic Pollution in Aquatic Ecosystem with a Case Study on Cherating River, Malaysia

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Highlights:

- Summary of microplastics pollution levels in different aquatic ecosystems worldwide.
- A first assessment of microplastics contamination in surface water of the Cherating river and the Cherating mangrove, Pahang, Malaysia was carried out.
- Fishing and tourism activities are suspected to be the main sources of microplastics pollution.

Abstract. Microplastics are emerging contaminants owing to their potential to adsorb and release pollutants from the environment, transferring these pollutants to the food web. Most marine microplastics come from the terrestrial environment, mainly from inland freshwaters that are direct receivers of runoff from urban, industrial, and agricultural areas. The present study investigated the occurrence of microplastics in surface water samples taken from the Cherating river and the Cherating mangrove, Pahang along with a review of recent studies on microplastics abundance in aquatic ecosystems. Three sampling sites were established (two sites along the river and one site in a mangrove in the downstream of the river). In the up- and midstream regions, the river passes by residential, fishery and tourism areas, while the mangrove is located close to Cherating Beach. The highest microplastics abundance was discovered in the midstream region, with an average abundance 0.0070 ± 0.0033 particles/m^3, followed by the mangrove (0.0051 ± 0.0053 particles/m^3). Fragments with a size of 0.5 to 1.0 mm and white-colored microplastics were prevalent. The findings are similar to those from other microplastic studies (e.g. in Aveiro and Lisbon, Portugal; New England, USA; Kingston Harbour, Jamaica), but lower than microplastics studies in Asia (e.g. Yangtze river estuary and Hangjiang river, China). Overall, the findings provide background information on microplastics pollution in aquatic ecosystems.

Keywords: *aquatic ecosystems; mangrove; microplastics; microplastics pollution; river.*

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1 Introduction

It has been well established that the majority of microplastics originate from plastic litter [1-3], which in turn is generated from high consumption of plastic commodities and subsequent inefficient waste management [4]. Alarmingly, the production of plastics has been growing rapidly since 1950 [5], such that it has reached global manufacturing of 348 million tonnes of plastic in 2017 [6], compared to 1.5 million tonnes in 1950 [5]. Waste management in developing countries is a major issue, as approximately 88% of municipal solid waste is disposed of at landfills or in open dumps [7], from where escape of plastic litter is not uncommon [8]. When plastic litter disintegrates due to environmental influences [1], it breaks down into particles in a size range of 5 mm to 1 μm; these particles are known as secondary microplastics [9]. Primary microplastics are produced with an intended use, such as industrial abrasives [10,11], pellets [12], and exfoliants [13]). In the environment, both secondary and primary microplastics are pervasively extant [1]. However, identification of microplastics in the environment is a strenuous process as no standards in methodology are present [1,14]. Nevertheless, there are plenteous reports on the abundance of microplastics in the aquatic environment [1]. Approximately 1.36 × 107 microplastics particles per km^{-2} were found in the Three Gorges Reservoir, China [15]. Similarly, 1660.0 ± 639.1 to 8925 ± 1591 microplastics particles per m^{-3} were reported in the Wuhan urban lakes located in China [16]. Victoria Harbor in Hong Kong, China is also highly polluted with microplastics, as 51 to 27,909 particles per m^{-3} were revealed [17]. Microplastics have been reported in the remotest part of the world, Antarctica, as well as in the Ross Sea, where a study found 0.17 ± 0.34 particles per m^{-3} [18]. In an extensive study of the Mediterranean Sea under Turkish territory, approximately 16,339 to 520,213 microplastics particles per km^2 have been reported [19].

In the same study, microplastics were also discovered from the intestines and stomachs of fish. The presence of microplastics in the aquatic ecosystem have resulted in accidental or intentional ingestion of microplastics by marine fauna [1]. It is often feared that ingestion of microplastics may lead to leaching of contaminants into the organs of marine fauna [20], as several studies have shown the affinity of microplastics towards adsorbing contaminants from the water [20-22]. These contaminants may include dioxin, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and others [20-22]. Thus, it is imperative to sufficiently document the abundance of microplastics in aquatic systems so that mitigating measures can be taken.

This paper was aimed at providing the status of microplastics abundance in aquatic ecosystems around the world, including lacustrine, fluvial and marine environments, by reviewing and compiling recent research papers. However, when it comes to Malaysia there is a lack of studies on the abundance of microplastics in both aquatic and terrestrial ecosystems. Therefore, this paper also presents primary data from a case study conducted to record the concentration of microplastics in the Cherating river, Pahang in order to provide a baseline. Moreover, the abundance of microplastics in areas of high anthropogenic activities is usually greater. Cherating is a popular tourist place in Malaysia and therefore it was hypothesized that microplastics would be present in relatively high concentrations in the Cherating river due to higher anthropogenic activities.

2 Methodology

2.1 Study Area

The Cherating river was chosen as the study object. It runs through a resort town in Pahang, on the east coast of peninsular Malaysia. The river is 16.1 km long and approximately 43 m wide and empties into the South China Sea. The estimated total amount of rainfall in Malaysia is between 3,000 to 3,200 per annum, with heavy rainfall during the northeast monsoon season (i.e. November to March) (Figure 1) [23]. The annual average temperature is between 25 °C and 26 °C.

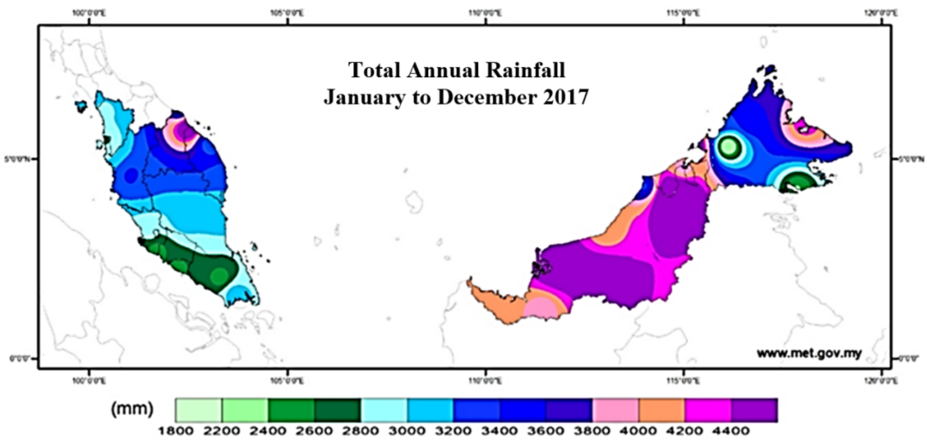

Figure 1 Total annual rainfall in Malaysia for 2017 [23].

Sampling sites were established along the Cherating river and in the Cherating mangrove. Two sampling sites were chosen to represent the river (upstream and midstream), while the mangrove area, located downstream in an estuary setting, was chosen as the third sampling site.

Upstream and midstream, the river passes through residential, fishery, and tourism areas, while the mangrove area is located close to Cherating Beach, which is a tourist destination because of its calm crystal-clear water and white sandy beach.

The site locations were recorded using a portable global positioning system (GPS) during sampling to ensure that the exact same area was sampled in all sampling events. Table 1 delineates the coordinates of the sampling sites, while the location of the sampling sites is presented in Figure 2. Three sampling events were conducted for each sampling site from November 2017 to August 2018. Anthropogenic activities that may contribute to the generation of microplastics were identified through observation of a 5-km radius area along each sampling site.

Table 1 Coordinates of the sampling sites.

Ecosystem	Site	Sampling Coordinates	
		Latitude	Longitude
River	**1** (upstream)	4°07’30.3"N	103°21’39.7"E
	2 (midstream)	4°07’44.4"N	103°23’34.3"E
Mangrove	**3**	5°52’05.0"N	102°29’33.0"E

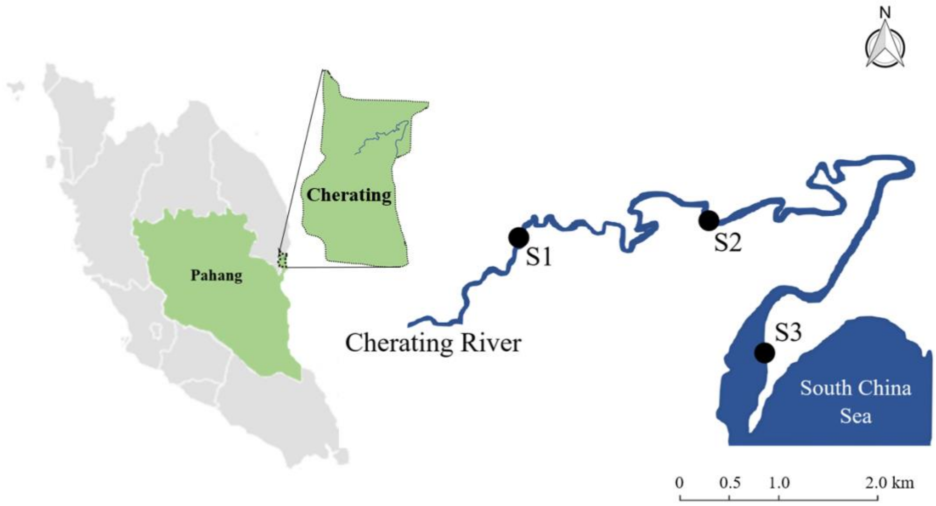

Figure 2 Map of peninsular Malaysia with the locations of the sampling sites. The numbers correspond to the locations in Table 1.

2.2 Sampling Method

Microplastics samples were collected from the surface water of the river using a conical nylon plankton net (100 µm; 0.3m in diameter x 1m long) by passing the flow of water through the net for one hour [17]. The microplastics retained in the net were washed into a container for further laboratory analysis [24]. The volume of the surface water samples collected was calculated by taking the product of river surface velocity, cross sectional area of the submerged portion of the net opening, and sample collection time [25]. The calculation was based on the following formula:

$$Volume\ sampled\ =$$
$$Water\ Velocity\ x\ Net\ Cross\ Sectional\ Area\ x\ Time \quad (1)$$

2.3 Sample Extraction and Laboratory Analyses

A container containing the surface water sample from washing of the net (i.e. 20 L) was shaken to mix the sample and the surface water was passed through a set of Tyler sieves with mesh size 5.0 mm, 1.0 mm and 0.1 mm. The microplastics that were retained by the sieves were extracted using steel tweezers. The extracted microplastics were then treated with 20% alcohol solution overnight.

2.4 Identification, Classification, and Quantification of Extracted Samples

The extracted microplastics were identified based on their size, type, and color (Table 2) using a binocular dissection microscope equipped with a digital eye-piece camera (Dino-Eye, AM4023X, 1.3 megapixels).

Table 2 Classification of microplastics.

Category	Description
Size	<0.1 mm, 0.1-0.5 mm, 0.5-1.0 mm, 1.0-5.0 mm [26]
Type	Line (fibrous), fragment (hard, jagged, angular), film (thin, flimsy), foam (lightweight, sponge-like), and pellet (hard, cylinders, disks, spherules) [27]
Color	Transparent, black, blue, red, yellow, white, and others [28]

2.5 Statistical Analysis

The unit of microplastic abundance in the surface water is reported as the number of particles per cubic meter (particles/m^3). The difference between the microplastics concentrations between the three locations was calculated with one-way analysis of variance (ANOVA, $p < 0.05$) using Microsoft Excel.

3 Results and Discussion

3.1 Microplastics in Present Study

3.1.1 Abundance of Microplastics in Present Study

Microplastics were present in all surface water samples from the Cherating river and the Cherating mangrove, with an average abundance of 0.0042 ± 0.0033 particles/m^3 (Table 3). A statistically significant difference of microplastics abundance was observed between the sampling locations [ANOVA, $F(1,4) = 11.95$, $p = 0.03$].

Table 3 Abundance of microplastics in surface water of study sites.

Ecosystem	Site	Microplastics abundance (particles/m^3)
River	**1**	0.0005 ± 0.0003
	2	0.0070 ± 0.0033
Mangrove	**3**	0.0051 ± 0.0053
Average		**0.0042 ± 0.0033**

The greatest microplastics pollution was identified in the middle region of the river, with an average abundance of 0.0070 ± 0.0033 particles/m^3. The highest incidence of contamination is attributed to the possible contributions from intense fishing and tourism activities that were present from the river's midstream to the downstream.

The Cherating mangrove, which is located in the downstream of the river in an estuarian setting, has undoubtedly been impacted by microplastics, which likely derived from the intensive fishing activities in the area, intensified by riverine transport and the water current. A recent study suggests that anthropogenic activities combined with surface current are major drivers of the presence of microplastics in mangroves, while strong wind could increase the dissipation of floating microplastics [29,30]. Another potential source of microplastics is improper solid waste management, for example illegal dumping observed near the sampling locations. Similar sources of microplastics input have been found in the Citarum river, Indonesia, where plastic manufacturers and defective waste management promote waste plastic entering into the river ecosystem [31].

In general, the findings of the present study are comparable with similar studies conducted in Southern Europe, such as in Aveiro (0.002 ± 0.001 particles/m^3) and Lisbon in Portugal (0.033 ± 0.021 particles/m^3) [32], as well as in the Southern Atlantic, New England, USA (0-14.1 particles/m^3) [33], and Kingston Harbour, Jamaica (0-5.73 particles/m^3) [34]. However, they were comparatively lower compared to studies in Asia, for example in the Yangtze river estuary

(2,516.7 ± 911.7 particles/m^3) [24] and the Hangjiang river in China (2,933 ± 305.5 particles/m^3) [35]. Overall, the variation in microplastics concentrations among the sampling sites may have been a result of differences in anthropogenic impacts, point sources of microplastic input, as well as the influences of natural factors such as water current, wind, and river transport [36].

3.1.2 Type, Size and Color Distribution of Microplastics in Present Study

Microplastics in the form of fragments were prevalent in the Cherating river (Table 4), which may have originated from the degradation of hard-plastic items such as food containers and drinking bottles. These plastic items may have been discarded from various tourism activities carried out along the river and disposed directly into the river or onto the riverbank and washed into the river by surface runoff [37]. Similar findings have been observed in Guanabara Bay, Brazil, where fragments constituted >55% of the total microplastics abundance [38]. Additionally, line microplastics were widespread in location 2 (22%) and location 3 (21%). Fishing activities, which also play a significant role in the study area, are a potential source of line microplastics.

Table 4 Characteristics of microplastics along the Cherating river.

Characteristics	Percentage composition (%)		
	Site 1	**Site 2**	**Site 3**
Type			
Line	9	22	21
Fragment	**55**	17	**67**
Film	36	**56**	12
Foam	0	5	0
Pellet	0	0	0
Size (mm)			
< 0.1	10	5	4
0.1 - 0.5	30	22	25
0.5 - 1.0	**50**	**39**	**46**
1.0 - 5.0	10	6	25
Color			
Transparent	20	28	4
Black	10	17	21
Blue	0	0	0
Red	0	0	0
Yellow	0	0	0
White	**50**	**55**	**38**
Others	20	0	37

* Highest percentage indicated with bold typeface

Microplastics of size fractions 0.5 to 1.0 mm were the most prominent in sites 1, 2, and 3, at 50%, 39%, and 46%, respectively. A similar finding was observed in the lower reaches of the Yangtze River, China [39]. The high microplastics abundance of larger size classes (>0.5 mm) presupposes that smaller size classes of microplastics ultimately sink into deeper segments, probably because of the high surface-to-volume ratio, which favors biofouling. Constant fragmentation has been discussed in the literature, since particles with smaller sizes are more persistent than larger ones due to their higher surface area, raising the probability to be ingested or filtered by organisms in the marine food web [40,41].

White microplastics were prevalent in locations 1, 2, and 3, accounting for 50%, 55%, and 38%, respectively. Figure 1 displays some of the microplastics extracted from Cherating. Several studies found that light-colored microplastics accounted for the majority of microplastics in marine environments [42].

The prevalence of light-colored microplastics may reflect the visual preferences of aquatic biota because they resemble food [43]. For instance, white-colored and transparent microplastics were most commonly collected in Asian clams (*Corbicula fluminea*) [44]). Nevertheless, information on color preference, especially among invertebrates, remains uncertain and requires closer investigation.

3.2 Abundance of Microplastics in Aquatic Ecosystem

3.2.1 Microplastics in Lakes

The concentration of microplastics has been reported in several lakes worldwide. Microplastics densities were similar over three years of sampling (2014-2016) in Lake Winnipeg, Canada, the 11th largest freshwater body in the world [45]. In general, most of the microplastics studies in lakes have been conducted in China, the world's largest producer of plastics at nearly 60 million tonnes/year [4]. Dongting Lake and Hong Lake are important lakes in the middle reaches of the Yangtze river, which play a significant role in flood regulation, fishery, tourism, and water supply for local agriculture and industry. It undoubtedly releases vast amounts of microplastics into the lake ecosystem [46].

Similarly, anthropogenic activities are known as significant contributors to microplastics pollution in Poyang Lake, particularly from the effluent of a wastewater treatment plant (WWTP) [47]. Sha Lake, Nantaizi Lake, and Nan Lake in China were also found to have high microplastics concentrations, at 6390 ± 862.7, 6162.5 ± 537.5, and 5745 ± 901.6 items/m^3, respectively, from a nearby WWTP [16]. Apart from that, high microplastics abundance near tourist destinations suggests tourism as an important contributor, as detected in Qinghai Lake, China's largest inland lake [48]. Studies conducted in the Italian Subalpine Lakes [49] and Dong Lake, China [16] have reported similar findings.

Table 5 Concentrations of microplastics in selected lakes worldwide.

Location	Concentration	Composition	Reference
Hong Lake, China	1800 items/m^3	Polypropylene	[47]
Poyang Lake, China	240 items/m^3	Polypropylene	[47]
Dongting Lake, China	900-2800 items/m^3	Polyethylene, polypropylene	[46]
Qinghai Lake, China	0.05×10^5 to 7.58×10^5 items/km^2	Polyethylene, polypropylene	[48]
Sha Lake, China	6390 ± 862.7 items/m^3	Polyethylene terephthalate and polypropylene	[16]
Dong Lake, China	5914 ± 1580.7 items/m^3	Polyethylene terephthalate and polypropylene	[16]
Taihu Lake, China	3.4-25.8 items/L	Cellophane, polyethylene terephthalate, polyester, terephthalic acid and polypropylene.	[50]
Lake Chiusi, Italy	2.68-3.36 items/m^3	NA	[51]
Lake Winnipeg, Canada	193,420 ±115,567 items/km^2	NA	[45]
Italian Subalpine Lakes	25000-40000 items/km^2	Polyethylene, polystyrene, polypropylene	[49]

3.2.2 Microplastics in Seas

Microplastics are heterogeneously distributed throughout the global seas (Table 6). Astoundingly, up to 1400 to 8100 items/m^3 have been discovered in the surface water of Zhubi Reef, South China Sea, which is much higher than the values reported from other ocean areas [52]. It is believed that Zhubi Reef is polluted with microplastics that originate from the intensive fishing activities in the area as well as emissions from coastal cities [52]. Nevertheless, the abundance of microplastics is closely interrelated not only with anthropogenic activities but also with ocean currents and meteorological conditions [50]. Hence, it is worth noting that large plastics break down gradually as they are transported by ocean currents from the source [53]. Previous studies have proposed that strong winds could increase the dissipation of floating microplastics [29]. Moreover, the release of microplastics entrapped in sea ice during melting may also contributes to the number of microplastics in the sea [54]. Of potential significance is that sea ice has been suggested to be an important means of transport and temporal sink for these contaminants. It is therefore reasonable to conclude that the microplastics found in the sea may originate from land or other sea areas.

Furthermore, a recent study has reported that the deep sea is the final sink for the microplastics and the concentration (i.e. 70.8 items/m^3) to be of the same order as in surface waters [55]. This suggests the possibility of vertical re-distribution of microplastics within the water column [26]. The discovery of microplastics in almost every environmental part of the sea (surface water, sea ice and deep sea) reveals that the sea is not immune to the entry of microplastics pollutants into its ecosystems.

Table 6 Summary of microplastics pollution in various seas worldwide.

Location	Concentration	Composition	Reference
Zhubi Reef, South China Sea	1400 to 8100 items/m^3	Polypropylene and polyamide	[52]
Bohai Sea, China	0.33 ± 0.34 items/m^3	Polyethylene, polypropylene, Polystyrene, polyethylene Terephthalate, polyvinyl phloride, polyurethane, and acrylonitrile	[56]
North Yellow Sea	545 ± 282 items/m^3	Polyethylene, polypropylene and polyethylene/ethyl acrylate copolymer	[57]
Rockall Trough, Scotland	70.8 items/m^3	Not given	[55]
Gulf of Bothnia (Baltic Sea)	8 to 41 items/L of melted ice	Not given	[58]
Chukchi Sea	0.23 ± 0.07 items/m^3	Polypropylene, polyethylene Terephthalate and rayon	[59]
Bering Sea	0.05 ± 0.02 items/m^3	Polypropylene, polyethylene Terephthalate and rayon	[59]
Arctic Central Basin	0.7 items/m^3	PET and polyacrylonitrile	[26]
South China Sea	0.045 ± 0.093 items/m^3	alkyd resin, polycaprolactone, poly ethyl acrylate, polystyrene, synthetic polyurethane rubber, polypropylene-polyethylene copolymer, polyester terephthalic acid and other polymers.	[60]

3.2.3 Microplastics in Mangroves

Microplastics were pervasive in mangrove environments around the world that have been surveyed (Table 7).

Table 7 Summary of microplastics pollution in various mangrove environments worldwide.

Location	Concentration	Composition	Reference
Douro Estuary, Portugal	17.06 items/100 m^3	Not given	[61]
Changjiang Estuary, China	157.2 ± 75.8 items/m^3	Polyethylene, polypropylene, polyester, polyamide	[62]
Hunter Estuary, Australia	431-1892 items/m^3	Not given	[63]
Charleston Harbor Estuary, South Carolina, USA	3-36 microplastics/L	Not given	[64]
Winyah Bay	30.8 ± 12.1 particles/L	Polyethylene, polypropylene	[64]
Bahía Blanca Estuary (Southwestern Atlantic)	5900 to 782,000 items/m^3 (Van Dorn) 42.6 to 113.6 items/m^3 (plankton net)	Polyester, polyamide, acrylic, polypropylene, polyolefin	[65]
Oujiang Estuary, China	680.0 ± 284.6 items/m^3	Polypropylene, polyethylene, polytetrafluoroethylene, polyvinyl chloride	[66]
Jiaojiang Estuary, China	955.6 ± 848.7 items/m^3	Polypropylene, polyethylene, polytetrafluoroethylene, polyvinyl chloride	[66]
Minjiang Estuary, China	1245.8 ± 531.5 items/m^3	Polypropylene, polyethylene, polytetrafluoroethylene, polyvinyl chloride	[66]
Cherating Mangrove, Malaysia	0.0051 ± 0.0053 items/m^3	Not available	Present study

Rodrigues, *et al.* in [61], who investigated the contamination of an urban impacted estuary (Duoro estuary), revealed that microplastic density varied significantly between seasons and estuarine areas. The highest microplastics concentrations were observed in winter (21.97 ± 8.82 items/100m^3) and spring (23.98 ± 10.61 items/100m^3), in middle area of the estuary. Nevertheless, the concentration of microplastics was generally higher in summer and followed freshwater inflow events in Hunter Estuary, Australia [63].

The concentration of microplastics in the Changjiang estuary, China was higher in July than in February and May, which is highly attributable to higher river discharge [62]. It is estimated that 16 to 20 trillion microplastic particles, weighing 487.7 to 821.8 tonnes, entered the sea through the surface water layer of the Changjiang estuary in 2017.

3.2.4 Microplastics in River

The number of studies on the abundance on microplastics has been increasing over the years. Table 8 summarizes some of the recent studies on the concentration of microplastics in alluvial ecosystems. Eo, *et al.* [37] reported that the abundance of microplastics at the river surface was three times higher than midwater. According to their estimates, the Nakdong river would have been transporting 5.4 to 11 trillion (by number) or 53.3 to 118 tons (by weight) of microplastics in 2017.

Simon-Sánchez, *et al.* [67] concluded in their study that rivers bring microplastic to the ocean. Hence, there is the established understanding that microplastics are transported to seas from rivers all over the world. However, Xiong, *et al.* [68] examined the microplastics load in the Yangtze river in China, which is notorious for being the largest ocean polluter, and concluded that the Yangtze river may not be contributing a high load of microplastics to the sea due to several factors, including dams in the upper stream, dilution of microplastics in larger catchment areas, and others. This highlights the importance of unbiased, extended monitoring of microplastics in the environment. McEachern, *et al.* [69] used water samples and a plankton net to take microplastics samples. The results for the plankton net are given in Table 8. They discovered that higher amounts of microplastics were extracted using water samples than the plankton net as microplastics escaped from the latter during plankton sampling. In Tampa Bay, Florida, United States, 0.25 to 7.0 particles/L of microplastics were discovered. According to their estimate, approximately 4 billion microplastics were present in Tampa Bay.

Table 8 Concentrations of microplastics in selected rivers of the world.

Location	Concentration	Composition	Reference
Nakdong river, South Korea	293 ± 83 particles/m^3 (upstream) 4760 ± 5242 particles/m^3 (downstream)	Polypropylene, polyester	[37]
Rivers in the Tibet Plateau	483-967 items/m^3	Polyethylene terephthalate, Polyethylene, Polypropylene, Polystyrene, Polyamide	[70]
Wei river, China	3.67-10.7 items /L	Polyethylene, Polyvinyl chloride, Polystyrene	[71]
Rivers in Japan	$1.6 \times 10^0 \pm 2.3 \times 10^0$ particles/m^3	Polyethylene, Polystyrene, Polypropylene	[72]
Yangtze river, China	1.95 × 105- 9.00 × 105 items/km^2	Polypropylene, Polyethylene, polystyrene, Nylon, polyoxymethylene, ethylene-vinyl acetate, cellulose	[68]
Ebro river, Northwest Mediterranean	3.5 ± 1.4 microplastics/m^3	Polyamide, polyethylene, Poly(methyl methacrylate), Polyester, polypropylene, Polyacrylate	[67]
Yarra river, Australia	158 items/month	Polystyrene, CP	[73]
Chicago river, Illinois, United States	6,698,264 ± 3 929,093 items/m^2	NA	[74]
Tampa Bay, Florida, United States	1.2-18.1 particles/m^3	Polystyrene	[69]
Cherating river, Malaysia	0.004 ± 0.005 items/m^3	NA	Present study

4 Conclusion

This paper provides baseline information for the monitoring of microplastics in the surface water of the Cherating river and the Cherating mangrove, Pahang, Malaysia. Microplastics were present in all surface water samples, with an average abundance of 0.0042 ± 0.0033 particles/m^3. The midstream region of the Cherating river contained the highest microplastics concentration, with an average of 0.0070 ± 0.0033 particles/m^3, followed by the mangrove area, with an average of 0.0051 ± 0.0053 particles/m^3. The high microplastics abundance may originate from intense fishing and tourism activities that are present from midstream to downstream. Improper solid waste management, for example from illegal dumping, promotes the accumulation of microplastics in the environment. Most of the microplastics were fragments, 0.5 to 1.0 mm in size, and white in color. Future monitoring programs for microplastics in rivers and mangrove areas in peninsular Malaysia are recommended for the assessment of these anthropogenic pollutants over time.

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Appendix

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
0.000786	3	0.00726	0.00242	4.4E-06
0.000262	3	0.02704	0.009013	1.05E-06

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between groups	6.52E-05	1	6.52E-05	11.95239	0.028099	7.708647
Within groups	1.09E-05	4	2.73E-06			
Total	7.61E-05	5				