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REVIEW

Progress on microplastics research in the Yellow Sea, China[1]

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Abstract: Marine microplastics are a global problem and are causing considerable concern. As the largest marginal sea of the Western Pacific, the Yellow Sea is surrounded by China and the Korean Peninsula, and its coastal ecosystem is greatly affected by human activities. This article reviews the progress of microplastics research in the Yellow Sea in China, including studies on surface water, the seawater column, sediments, and marine organisms. The results indicate that plastic debris exists throughout the west Yellow Sea, with higher abundance of microplastics in water columns and sediments in the north part than those in the south part. Fibers <1 mm and transparent-colored particles dominated the samples collected. Polyethylene (PE), polypropylene (PP), and cellophane (CP) were the dominant debris types. The wide distribution of microplastics in the environment also results in animal ingestion. Sea cucumbers, accordingly, ingest more microplastic debris than other biologic taxa (zooplankton, shellfish, and fish) that have a bearing on their surrounding environment. By providing basic environmental assessment data regarding the Yellow Sea, this paper demonstrates that actions should be taken to reduce the consumption and emission of plastics into the environment.

Key words: microplastics, west Yellow Sea, seawater, sediment, biota.

1. Introduction

Microplastics are plastic particles <5 mm in diameter, and the occurrence of microplastics in the ocean has become a growing global concern over the last few decades. The existence of microplastics in the ocean was first reported by Buchanan (1971). Carpenter and Smith (1972) found that plastics were widespread throughout the western Sargasso Sea and recorded an average of 3500 pieces and 290 g per square kilometer one year later. To date, microplastics have been studied in freshwater, seawater, inland and coastal areas, rivers, estuaries (K. Zhang et al. 2018), nearshore and open ocean regions, at the surface, and in sediment (Gago et al. 2018). The sources of microplastics in the ocean are extensive, and most microplastics originate from personal care products, such as facial cleansers and cosmetics (Zitko and Hanlon 1991), drug delivery products (Patel et al. 2009), virgin plastic

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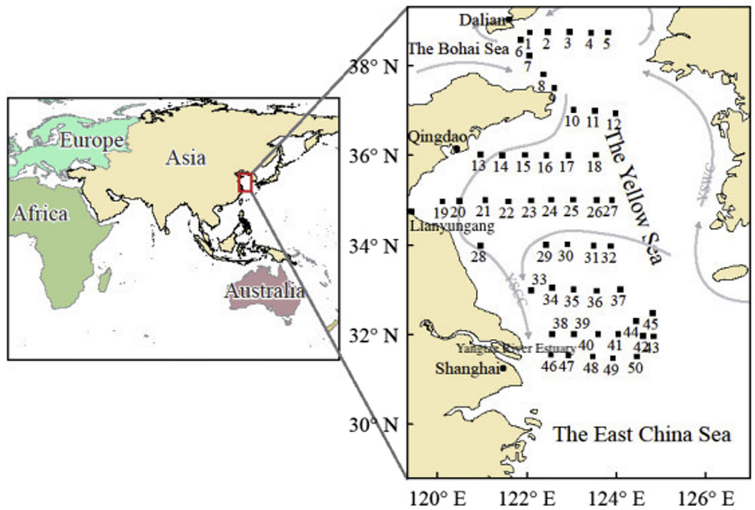
Fig. 1. Map of the Yellow Sea, China.



production pellets (Costa et al. 2010; Andrady 2011), and the breakdown of large plastic products (Thompson et al. 2004; Ryan et al. 2009). Most plastic materials are derived from fossil feedstock, such as natural gas, oil, or coal. Global plastic production reached 335 million t in 2016, with plastic production in China accounting for 29% of the total, followed by Europe and North America, accounting for 19% and 18%, respectively. Polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polyurethane (PUR), polyethylene terephthalate (PET), and polystyrene (PS) are common products, accounting for 80.7% of the entire output (PlasticsEurope 2018).

The length of the coastline in China is >18 000 km. The Yellow Sea (Fig. 1) is one of four offshore areas in China and has an area of ~0.4 million square kilometers. The Hangang River, Huaihe River, and Yalu River flow into the Yellow Sea, and the main coastal cities in China include Lianyungang, Yancheng, Nantong, Rizhao, Qingdao, Yantai, Weihai, Dalian, and Dandong. The population along the coast is ~5.1 million. The first study of microplastics in China occurred in the Yangtze Estuary in 2014 (Zhao et al. 2014), and the first research on the microplastics in the Yellow Sea was conducted in 2015 by Zhang et al. (2015). Comprehensive studies including studies on the surface water, sediments from sandy beaches and the seabed, and marine biota, have been carried out in the Yellow Sea in China (Table 1). Some reviews on microplastics in coastal environments on a national level, microplastics pollution in water, sediment, and zooplankton in the Yellow Sea, but fish, shellfish and other marine biota in this area have generally been ignored (Wang et al. 2019). Zhu et al. (2019) studied microplastics pollution in the oceans, but few studies specific to the Yellow Sea were mentioned. Another article on the microplastics in China only summarized the source and instruments of marine plastic particles (J. Wang et al. 2018).

The Yellow Sea coastal area in China has become a priority region for economic development and contributes greatly to the economy of China through its unique resources and strategic location. With the urbanization around the Yellow Sea, major human activities such as tourism, industry, fishery, and farming are becoming increasingly concentrated, causing a microplastics pollution that seriously threatens environmental safety and sustainable economic development in this area. The goals of this review are to summarize the research on the microplastics in the seawater, sediments, and marine biota in the Yellow Sea, to determine the research gaps in this area and to build a foundation for future work.

Table 1. Summary table of reviewed studies on microplastics in the Yellow Sea, China (in seawater, sediments, and biota).

Location	Sampling time	Sample	Sampling	Separation solution	Identification	Abundance	Size	Color	Shape	Composition	Reference
Zhengmingsi Beach, the northern coast of the Yellow Sea	2012	Sediments	By the naked eye	Forceps	—	PCBs ranged from 34.7 to 213.7 ng/g and from 21.5 to 323.2 ng/g; PAHs ranged from 136.3 to 1586.9 ng/g and from 397.6 to 2384.2 ng/g; DDTs ranged from 1.2 to 101.5 ng/g and from 1.5 to 127.0 ng/g	—	—	—	—	Zhang et al. 2015
The north wing of the Yangtze River Delta, an offshore wind farm in the Yellow Sea	2016	Surface water	Neuston net (333 μm)	35% H_2O_2	μ-FTIR	0.330 ± 0.278 items/m^3, 0.117 to 0.506 items/m^3	0.05–5 mm	Colored and black	Fiber, granule, and film	Polyethylene terephthalate (PET), followed by cellophane (CP) and polyethylene (PE)	T. Wang et al. 2018
		Sediment	Bottom grab	NaCl, NaI		2.58 ± 1.14 items/g (dry), 1.190–4.920 items/g (dry)		Transparent-colored	Fiber, granule, and film		
Parts of Yellow Sea coastlines in Shandong province	2015	Sediment	Clean stainless-steel shovel	Saturated sodium chloride solution (ρ = 1.2 g, cm−3); sodium iodide (ρ = 1.6 g, cm−3)	ATR-FTIR	1.3–14 712.5 N kg^{-1} (dry weight)	60% of the observed microplastics had a size range <1 mm	Transparent, colored	Pellets, foams, fragments, flakes, films, fibers, and sponges	Polyethylene (PE) and polypropylene (PP)	Zhou et al. 2018
The Yellow Sea in north China	2015	Sediment	A shovel	Density separation	ATR-FTIR	41 ind/28 stations	PS flakes<1 mm; PE pellets ranged of 4–5 mm; the PS foams and the fragments (PE or PP) within the intermediate size range	White, transparent, colored	Foams, pellets, flakes, and fragments	Polystyrene (PS), polyethylene (PE), and polypropylene (PP)	H. Zhang et al. 2018
The North Yellow Sea	2016	Seawater	25 L of surface seawater was sampled by Niskin hydrophore and poured through a 30 μm steel sieve	30% H_2O_2, and then NaCl solution (1.2 g/cm^3)	Micro-FTIR	545 ± 282 items/m^3	35.7%–83.5% of the total microplastics < 0.5 mm	Transparent, colored, black, white	Films, fibers, pellets, and granules	Polyethylene (PE), polypropylene (PP), and polyethylene/ethyl acrylate copolymer (PE/EA)	Zhu et al. 2018
		Sediment	0.1 m^2 Gray-O'Hara box corer	NaI solution (1.6 g/cm^3); 30% H_2O_2, and then NaCl solution (1.2 g/cm^3)		37.1 ± 42.7 items/kg dw	60.0%–96.6% of microplastics < 0.5 mm	Transparent, colored, black, white	Films, fibers, and granules	Polypropylene (PP), polyethylene (PE), polypropylene/polyethylene copolymer (PP/PE), and nylon	
The Yellow Sea	2016	Sediment	A stainless steel box sampler	NaCl with ρ = 1.20 g/mL, 30% H_2O_2	μ-FTIR	Northern Yellow Sea (NYS) and Southern Yellow Sea (SYS) were varied from 4.0 to 14.0 and 2.0–7.0 items/50 g (dw)	Ranged from 66.25 to 4982.59 μm, with a mean of 854.88 ± 698.6 μm	—	Fibers, fragments, films, and pellets	Rayon (RY), polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), and polyamide (PA)	Zhao et al. 2018
The North Yellow Sea	2017	Surface water	Manta trawl (333 μm)	30% H_2O_2	—	Concentration of 16 PAHs (16 PAH) was site-independent and ranged from 3400 to 120 000 ng/g	—	—	—	—	Mai et al. 2018

Table 1. (*concluded*).

Location	Sampling time	Sample	Sampling	Separation solution	Identification	Abundance	Size	Color	Shape	Composition	Reference
The Yellow Sea	2015	Seawater	Bongo nets (500 μm)	By hand under a stereomicroscope	μ-FT-IR	0.13 ± 0.20 pieces/m^3, ranged from 0.00 to 0.81 pieces/m^3	Ranged from 0.35 to 44.99 μm, with an average length of 3.72 ± 4.70 μm	—	Fragments, film, foam, and fiber	Low-density plastics polyethylene (PE) and polypropylene (PP)	Sun et al. 2018*a*
		Zooplankton		100% HNO_3		12.24 ± 25.70 pieces/m^3	Ranged from 9.86 to 996.75 μm, with an average of 154.62 ± 152.90 μm	—	Fiber, fragment, and pellet	Organic oxidation polymers, polypropylene (PP), polyethylene (PE), low-density plastics	
The coastal waters of China	2015	*Mytilus edulis*	Wild mussels: tweezers; farmed mussels: with the help of fishermen	30% H_2O_2, filtered NaCl solution	μ-FT-IR	Varied 0.9–4.6 items/g (wet weight) and 1.5–7.6 items/individual; with average 2.2 items/g and 4 items/individual	<250 μm in size ranged from 17% to 79% of the total microplastics; >1 mm arranged from 1% to 34%	—	Fibers, fragments, spheres, and flakes	Cellophane (CP), polyethylene terephthalate (PET), and polyester (PES)	Li et al. 2016
Huangdao district in Qingdao	2017	Wild *Mytilus galloprovincialis*	From the rocky coast of Huangdao district in Qingdao	10% KOH solution	μ-FT-IR	1.9–9.6 items/individual and from 2.0 to 12.8 items/g	Ranged from 25 μm to 5 mm	Variety of colors	Fibrous, fragments, granules	Cellophane (CP), polypropylene (PP), and polytetrafluoroethylene (PTFE)	Ding et al. 2018
The Yellow Sea	2016	Fish	Bottom trawl net (2.4 cm)	100% HNO_3	μ-FT-IR	0.41 MP/fish for all fish and 1.2 MP/fish for fish with plastic	Ranged from 16 to 4740 mm	—	Fibers, pellets, and fragments	Organic oxidation polymers, polyethylene (PE), and polyamide (PA)	Sun et al. 2019
Qingdao and Lianyungang	2016	Oysters	Purchased from local culture farms from 17 sites along the coastline of China	10% (*m*/*v*) KOH and 20 mL of 30% H_2O_2	μ-FT-IR	0.335 items/g or 2.295 items/individual	Mean size was 902.82 ± 782.99 μm, ranging from 20.34 to 4807.22 μm	—	Fibers, fragments, films, and pellets	Cellophane (CP), polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polyamide (PA), polystyrene (PS), polycarbonate (PC), and polyvinyl chloride (PVC)	Teng et al. 2019
Weihai, Yantai, Qingdao, Rizhao	2017–2018	Sea cucumber *Apostichopus japonicus*	Four sites located in the Yellow Sea	H_2O_2 (30%)	μ-FT-IR	0.39 items/g or 12.92 items/individual	—	Blue, transparent, black, red, purple, brown, and green	Fibers, fragments	Cellophane (CP), polyester, polyethylene terephthalate (PET), polyethylene (PE), polypropylene (PP), polyvinyl acetate (PVA), and polyacrylonitrile (PAN)	Mohsen et al. 2019

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2. Progress on microplastics research in the Yellow Sea, China

2.1. Concentration and characterization of microplastics in the seawater

According to the reviewed papers, the units used to describe the results of microplastics at the seawater surface are the number of microplastics per m^3. The concentrations of microplastics in the seawater of the Yellow Sea varied in different districts. The mean concentration of microplastics collected by a net with a mesh size of 500 μm throughout the west Yellow Sea was 0.13 ± 0.20 pieces/m^3, ranging from 0.00 to 0.81 pieces/m^3 (Sun et al. 2018*a*). The microplastics concentration at the sea surface in the north wing of the Yangtze River Delta, which were sampled by a net with 333 μm mesh size, was 0.330 ± 0.278 items/m^3, and ranged from 0.117 to 0.506 items/m^3 (T. Wang et al. 2018). This concentration is similar to that throughout the west Yellow Sea. The abundance of microplastics detected by a net with 333 μm mesh in the north Yellow Sea varied from 3 to 19 particles/100 m^3 or 0.012–0.231 mg/m^3 (Mai et al. 2018). Surprisingly, the average abundance of microplastics in the surface seawater of the north Yellow Sea was 545 ± 282 items/m^3 (Zhu et al. 2018); this value is approximately 4500 times higher than that reported by Mai et al. (2018). The cause of this phenomenon is that the samples were collected with a small-mesh size of Niskin water sampler with a 30 μm steel sieve.

The hydrological conditions and the developments of coastal cities, marine fisheries, and shipping were found to differ in four coastal areas. The abundance of microplastics was 0.33 ± 0.34 particles/m^3 (Zhang et al. 2017) or 7–162 particles per 100 m^3 (0.012–2.96 mg/m^3) (Mai et al. 2018) in the seawater of the Bohai Sea, 0.31 pieces/m^3 (Liu et al. 2018) or 0.167 ± 0.138 n/m^3 (Zhao et al. 2014) in the East China Sea, and 0.045 ± 0.093 particles/m^3 (Cai et al. 2018) in the South China Sea. All the samples were collected by a net with a mesh size of 333 μm, except these collected by Liu et al. (2018), who trawled for samples with a 500 μm mesh net. Compared to the other three areas, the abundance of microplastics in the seawater of the Yellow Sea is moderate.

Most of these present studies showed that the sizes of microplastics ranged from 0.025 to 5 mm, and these studies usually divided these sizes into groups: <0.5, 0.5–1, 1–2, 2–3, 3–4, and 4–5 mm (Zhao et al. 2018; Zhu et al. 2018). In the seawater, fibers and films were the main shapes in the north wing of the Yangtze River Delta (T. Wang et al. 2018) and the northwest Yellow Sea (Zhu et al. 2018), constituting 75.4% and 97.2%, respectively. However, fragments were the most popular shapes throughout the west Yellow Sea, accounting for 42% (Sun et al. 2018*a*). Transparent and colored microplastics accounted for a majority of the microplastics in the Yellow Sea, followed by black and white microplastics. In previous studies, marine debris was commonly examined by the naked eye (Morét-Ferguson et al. 2010) or by using a dissection microscope (Doyle et al. 2011), which led to potentially high error rates, especially for smaller particles. The most common compositions of plastic were PE and PP, with PET accounting for a small portion. We were pleasantly surprised that all the marine debris in the West Yellow Sea was analyzed by Fourier transform infrared (FTIR) spectroscopy, including ATR-FTIR, micro-FTIR, and μ-FTIR, all of which are reliable for microplastic analysis. FTIR microspectroscopy has been the most commonly used technology for microplastic testing in recent studies (Gago et al. 2018). In addition to FTIR spectroscopy, several techniques have been used to analyze the chemical compositions of microplastics, including carbon, hydrogen, and nitrogen (CHN) analysis (Morét-Ferguson et al. 2010), scanning electron microscopy (SEM) (Woodall et al. 2015), Raman spectroscopy (Lenz et al. 2015), and pyrolysis–gas chromatography (Fischer and Scholz-Böttcher 2017). In comparison, FTIR spectroscopy is the most commonly used method for microplastic analysis because the chemical composition of plastics can be determined, and the original source of the debris can be traced. One of the deficiencies in

FTIR spectroscopy technique was that it is time consuming, as the microdebris samples are analyzed one at a time; the other deficiency is that only a small part of the surface morphology of plastic particle can be analyzed. Nevertheless, FTIR has been extensively used in recent studies.

2.2. Concentration and characterization of microplastics in the sediments

The units that have been used to express the abundance of microplastics in sediments are diverse. Microplastics in the sediments of the south Yellow Sea ranged from 2.0 to 7.0 items/50 g of dry weight sediment, and that of the northwest Yellow Sea varied from 4.0 to 14.0 items/50 g of dry weight sediment (Zhao et al. 2018), which is twice the abundance of microplastics in the southwest Yellow Sea. The north Yellow Sea is surrounded by the Liaodong Peninsula, Shandong Peninsula, and Korean Peninsula. Thus, human activities have a great impact on microplastic pollution in this area. The Bohai Sea has a higher concentration of microplastics than the Yellow Sea, and due to the water exchange between the Bohai Sea and the north Yellow Sea, the concentration of microplastics in the north Yellow Sea is higher than that in the other areas of the Yellow Sea.

The results of research on microplastics by different teams in the same area are distinct. One team researched the microplastics in the sediments of the north Yellow Sea, and the results proved that the mean concentration of microplastics was 37.1 ± 42.7 items/kg of dry weight sediment (Zhu et al. 2018), which is much less than that measured by Zhao et al. (2018). T. Wang et al. (2018) verified that the concentration of microplastics in the north wing of the Yangtze River Delta was 2.58 ± 1.14 items/g of dry weight sediment, ranging from 1.190 to 4.920 items/g of dry weight sediment. The concentrations of microplastics in the north Yellow Sea were higher than those in the south part, and the coastline areas were found to possess a large number of microplastics. The abundance of microplastics in the sediments was 171.8 items/kg of dry weight sediment (Zhao et al. 2018) in the Bohai Sea, and this value was more than 250 items/50 g sediment (Qiu et al. 2015) in the South China Sea, which was higher than that in the Yellow Sea.

The shapes of marine particles in beach sediments were distinct from those in the seabed sediments. Pellets and foams were the main shapes in the intertidal zone (H. Zhang et al. 2018; Zhou et al. 2018), and fiber was the primary shape in the seabed sediments (T. Wang et al. 2018; Zhao et al. 2018; Zhu et al. 2018). The colors of the microplastics in the sediments were dominated by transparent and colored items, which was similar to the pattern observed in the surface seawater. PE and PP were the main chemical compositions of microplastics in the sediments, followed by PS, PET, and nylon.

2.3. Concentration and characterization of microplastics in marine biota

The Yellow Sea possesses many fishing grounds, such as the Yanwei, Shidao, and Lvsi fisheries, which are rich in resources. The Yellow Sea is also an important aquaculture region, marine products mainly comprise fishes, mussels, oysters, and sea cucumbers. The concentration of microplastics in marine biota has been depicted by the unit item per g, item per individual, or item per m^3 (combined with the zooplankton abundances). In wild *Mytilus edulis*, the mean abundance of microplastics was 2.7 items/g or 4.6 items/individual, and this value was 1.6 items/g or 3.3 items/individual in farmed mussels (Li et al. 2016). The abundance of microplastics was higher in mussels from wild areas than in those from farmed areas. The numbers of microplastics in *Mytilus galloprovincialis* varied from 1.9 to 9.6 items/individual and from 2.0 to 12.8 items/g (Ding et al. 2018). The average abundance was similar to the published data of 2.7 items/g or 4.6 items/individual. However, the result showed that farmed *M. galloprovincialis* experienced more plastic contamination than the wild specimens, completely contrary to the previous study, which were reported by Li et al. (2016). Qu et al. (2018) demonstrated a positive linear relationship between the microplastic level in wild mussels and that in the waters. Oysters are important commercial species, and as keystone organisms for environmental quality monitoring, they can provide valuable ecosystem feedback. Teng et al. (2019) investigated the oysters along China's coastline; they chose the oysters from Qingdao and Lianyungang as representative samples from the Yellow Sea. The abundance in the samples from Qingdao was 0.42 items/g or 1.96 items/individual and that in the samples from Lianyungang was 0.25 items/g or 2.63 items/individual. The mean value of microplastics in oysters from the Yellow Sea was close to that in oysters from the Bohai Sea, and much lower than those in oysters from the East China Sea and the South China Sea. The average number of microplastics ingested by cultured sea cucumbers along the Shandong Province near the Yellow Sea was 0.39 pieces/g or 12.92 pieces/individual, which was higher than that in sea cucumbers in the Bohai Sea (Mohsen et al. 2019). Additionally, 19 species of fish were collected with a bottom trawl; 34% of fish contained plastics, with 0.41 pieces/fish on average. The highest percentage of microplastics/fish was detected in the yellow croakers (*Larimichthys polyactis*), and the fish with the lowest percentage of plastics were *Pampus argenteus* and *Psenopsis anomala* (Sun et al. 2019). The distribution of fish containing plastics in the south and north Yellow Sea was higher than that in the middle part. This study reveals that the abundance of microplastics in fish is impacted by regions and species.

As grazers, zooplankton provide an energy pathway from the primary trophic level to predators. Eleven zooplankton taxonomic groups, including Stomatopoda, fish larvae, Medusozoa, Siphonophorea, Chaetognatha, Luciferidae, Brachyura larvae, Copepoda, Euphausiacea, Amphipoda, and Thaliacea, were analyzed in the laboratory after transfer from the ocean. Zooplankton were sampled with Bongo nets (500 μm mesh size). The results indicated that microplastics were detected in each group of the 11 zooplankton communities. The number of microplastics varied in the different zooplankton groups; Thaliacea retained the fewest number of microplastics with 0.07 MP/zooplankton, and the number of microplastics in the larger stomatopods was 1.17 MP/zooplankton, and this group contained the most microplastics. The number of microplastics ranged from 0 to 151.34 pieces/m^3 with an average of 12.24 ± 25.70 pieces/m^3 after the bioaccumulated concentrations were combined with the zooplankton taxa abundances (Sun et al. 2018*a*). The abundance of microplastics ingested by the zooplankton (sampled by Bongo nets with a mesh size of 500 μm) in the East China Sea was 19.7 ± 22.4 pieces/m^3 (Sun et al. 2018*b*). In the South China Sea, the abundance of microplastics was 4.1 pieces/m^3 and 131.5 pieces/m^3 for different nets (500 and 160 μm in size, respectively) (Sun et al. 2017). The zooplankton sampled in the East China Sea contained more microplastics than those in the Yellow Sea and the South China Sea due to the large abundance of zooplankton taxa in the East China Sea.

However, in contrast to the microplastics in sediments, fibers were the most popular microplastic shape in the marine biota, including shellfish, sea cucumbers, 11 zooplankton communities, and 19 species of fish (Li et al. 2016; Ding et al. 2018; Sun et al. 2018*a*, 2019; Mohsen et al. 2019; Teng et al. 2019). The colors of the microplastics ingested by marine organisms were not reported except for those in the wild *M. galloprovincialis*, which were described to have a "variety of colors" (Ding et al. 2018; Mohsen et al. 2019). The microplastics ingested by the zooplankton in the west Yellow Sea were mainly composed of organic oxidation polymers, PP, and PE. The main composition of the marine debris in the mussels, *M. edulis* and *M. galloprovincialis*, was confirmed to be cellophane (CP). Among all the reviewed papers, only five papers classified CP as the main chemical composition of the collected particles (Li et al. 2016; Ding et al. 2018; Wang et al. 2018; Mohsen et al. 2019; Teng et al. 2019). A few articles on microplastics worldwide claimed that CP was the dominant component of microplastics (Castillo et al. 2016; Jabeen et al. 2017; Gago et al. 2018). There are many different types of plastics, and they can be grouped into two main polymer families: thermoplastics (acrylonitrile butadiene styrene (ABS), polycarbonate (PC), PE, PET, PVC, polymethyl methacrylate (PMMA), PP, PS, expanded polystyrene (EPS)) and thermosetting polymers (epoxide (EP), phenol-formaldehyde (PF), PUR, polytetrafluoroethylene (PTFE), unsaturated polyester resins (UP)) (PlasticsEurope n.d.). Apparently, CP is outside the range of plastic. It remains to be determined whether CP should be cataloged as plastic. Only one review article focused on persistent organic pollutants (POPs); this article focused on plastic resin pellets in sandy beach sediment (Zhang et al. 2015) and showed that industrial products, agricultural activity, and the use of fossil fuel around the area could impact the effect of microplastics on the absorption of POPs in the environment.

In summary, microplastics are everywhere in the Yellow Sea. Compared to the Bohai Sea, the East China Sea, and the South China Sea, plastic waste pollution in the Yellow Sea is at a moderate level. According to the surveys, there has been an upward trend in the abundance of plastic pollution in this region over time. Moreover, sediments in the Yellow Sea have the highest rate of contamination by microplastics in relation to the water and marine biota. Clearly, most microplastics settle to the bottom of the ocean. Sea cucumbers, accordingly, ingest more microplastic debris than other biologic taxa (zooplankton, shellfish, and fish) that have a bearing on their surrounding environment. The fact that the seafood contains microplastics reminds us that microplastics contamination poses a risk to food safety.

3. Prospect

In the past few years, comprehensive studies on microplastics, including studies on surface seawater, sediment, mussels, zooplankton taxa, and fish, have been performed in the Yellow Sea. However, some issues regarding the microplastics in the environment remain to be solved. The following issues should be considered for further research in the Yellow Sea.

1. Methodology. The current microplastics collection methods differ, leading to a difficulty in comparing the spatiotemporal distribution of microplastics.
2. Ecotoxicology. To the best of our knowledge, microplastics in the environment can absorb the POPs around them. Whether these carriers could release POPs to a new environment remains unclear. It has not yet been resolved if the microplastics ingested by marine biota, including mussels and zooplankton groups, are toxic or harmful to the organisms (e.g., growth, mortality, and fecundity).
3. Marine food web transfer. Once ingested by marine biota, microplastics can enter the food chain (web). It should also be explored whether biotransfer and bioaccumulation occur.
4. Risk assessment. It is important to conduct the evaluations of the impact of microplastics on different marine biota and human beings based on the characteristics of microplastics in the Yellow Sea.
5. Prevention. Technically, artificially accelerating the process of microplastic degradation in the ocean is not likely possible. At present, the only way to accelerate this process is by relying on the self-purification capacity of the environment. Therefore, the most important way to solve this environmental problem is to control it at the source, such as by reducing the emissions of plastics. More research is necessary on how to reduce the emissions and the effects of reducing emissions is necessary.

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