Microplastic pollution characteristic in surface water and freshwater fish of Gehu Lake, China

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Abstract

Much more attention has been poured into microplastic pollution in freshwater systems recently. In the present study, the pollution of microplastics (MPs) in surface water and freshwater fish (crucian carp, etc.) were investigated from Gehu Lake, which is the second largest lake in southern Jiangsu after Taihu Lake. The result manifested that the average abundance of MPs was respectively 6.33 ± 2.67 n/L for surface water and 10.7 items per individual for freshwater fish. The distribution of MPs in Gehu Lake varied from place to place, with the highest abundance of MPs was observed in the two estuaries of the eastern part of the lake. It was speculated that topographical factors and human factors were the main factors affecting the abundance and distribution of MPs. Transparent fibers were the main type of MPs in water samples, accounting for 69.70% of all detected particles. Meanwhile, most of the MPs ingested by freshwater fish were fibers, and the main colors were transparent and blue. In addition, the dominant size of the MPs was between 0.1 mm to 0.5 mm in water and fish samples. Moreover, PES, Man-made fiber, and PP were the dominant polymer types in the surface water and fish samples. The results of this investigation can provide basic data for the research and management of MPs in freshwater systems.

Introduction

Microplastic pollution is a global environmental threat (Hu et al. 2020). However, there are much more researches on marine microplastic pollution than freshwater microplastic pollution, probably because the marine ecosystem is considered to be the final sink of MPs. It is estimated that inland freshwaters are important pathways for MPs to the oceans (Lebreton et al. 2017). In the inland areas, rivers and lakes are the direct recipients of runoff from urban, industrial, and agricultural areas (Eriksen et al. 2013). However, researches on MPs pollution in inland freshwater are relatively insufficient. Moreover, MPs pose the greatest threat to different ecosystems and organisms due to their potential physical and chemical hazards (Lu et al. 2018; Ward and Kach 2009). Such as shellfish, fish (Digka et al. 2018; Wright et al. 2013), Seabird (Amélineau et al. 2016), Sea turtle (Duncan et al. 2018) even mammals may mistakenly eat microplastic particles as food, which will cause damage to biological organs, obstruction of the gastrointestinal tract and growth restriction (Wright et al. 2013). Therefore, a system for MPs monitoring is urgently needed.

At present, the pollution of freshwater MPs has attracted increasing attention, and reports on freshwater MPs have gradually increased worldwide. Many sources can cause MPs pollution in freshwater ecosystems, including weathering degradation of plastic waste, wastewater treatment plant (WWTP) sewage discharge (Cole et al. 2011; Mintenig et al. 2017), and surface runoff (Yuan et al. 2019; Hu et al. 2020), etc. Lakes serve as the major sink of MPs in freshwater ecosystems, because plastic debris may accumulate in the lake for a long time. In Europe, the Danube (Lechner and Ramler 2015), Rhine (Mani and Burkhardt-Holm 2020), Elbe, Neckar, Seine (Unice et al. 2019), and Marne were all polluted by MPs. In North America, the existence of MPs was also found in the St. Lawrence River (Crew et al. 2020) in Canada and the North Shore Channel of Chicago in the United States. China as the world's largest producer of plastic raw materials (Perryman et al. 2015), and data from several studies suggest that the

wide occurrence of MPs pollution in some of China's important lakes, such as the Taihu Lake (Su et al. 2016), the Dongting Lake, Hong Lake (Wang et al. 2018), the Poyang Lake (Yuan et al. 2019) and two remote lakes in Tibet plateau (Zhang et al. 2016). Estuary has been selected as a hotspot (Fok and Cheung 2015; Simon-Sánchez et al. 2019) for research on MPs because they are the gateway for MPs to enter the marine environment from inland water. Research on estuary MPs was mainly limited to the large estuary in China (Zhang et al. 2019). A quintessential example (Zhao et al. 2014) should be cited that first studied the abundance of MPs in the Yangtze River Estuary, and found that the average abundance of MPs was 4137.3 ± 2461.5 n/m³. However, the concentrations and distribution patterns of MPs in different freshwater habitats are highly variable, more in-depth investigations and studies are still indispensable.

Gehu Lake is the second largest lake in southern Jiangsu after Taihu Lake (Tian et al. 2020), and it provides mankind with abundant freshwater and biological resources. In this study, the abundance, distribution, and morphological specificity of MPs in surface water and fish of Gehu Lake were investigated. Furthermore, the presence of MPs in fifteen different fishes in Gehu Lake was also examined. The specific objective of this study was to provide general information about the current situation of microplastic pollution in the surface water and gastrointestinal tracts, gills of freshwater fishes from Gehu Lake. This study seeks to obtain data that will help to address these research gaps and provide basic data for monitoring microplastic pollution in freshwater.

Materials And Method

Sampling location and sample collection

Gehu Lake, also known as West Taihu Lake, is located in the west of Taihu Lake. The total watershed area of Gehu Lake is 164 km², 22.1 km long from north to south, 9 km wide from east to west, and an average water depth of 1.2 m. Gehu Lake is responsible for communicating the two major water bodies of the Yangtze River and Taihu Lake, carrying out the paramount functions of water volume adjustment, flood prevention, and transportation of clear water. This study selected 8 points (Supplementary Table S1), including six estuaries and two other sites around Gehu Lake for research, as shown in Fig. 1. Water and fish samples were collected in January 2019. Briefly, the surface water was collected from each location (0–20 cm in depth) by using a clean submersible pump. Take three parallel samples at each site. Then filter with a 48µm filter, and wrap the filter with tin foil to prevent sample loss. To prevent contamination and always avoid contact with plastic materials, all sampling tools between each site need to be rinsed with distilled water more than three times. The samples were fixed in tin foil at 4°C until laboratory analysis. Moreover, sampling sites were marked as the S1-S8 series.

The freshwater fish were 15 target fish species captured using gill nets, and two replicate individuals of each species of fish having similar body weights and total lengths were randomly selected. A total of 30 freshwater fish from 8 locations were collected, and the fish samples were cooled in ice packs and then taken back to the laboratory. The total length (cm) and weight (g) of each fish were measured and stored

the samples at -20°C before analysis. In addition, fish samples were marked as the A-O series. The weight and length of each fish sample were recorded in Table 1.

Table 1. Species, sizes, body weight and abundances of MPs from fishes in Gehu Lake

Species	Abbreviation	Average Weight (g)	Average Length (cm)	Average GITs weight (g)	Average Gills weight (g)	Average Number of Microplastics
Crucian	A	223	22.5	7	5	17
Catfish	B	87	25.0	4	5	10
Culter alburnus	C	388	40.0	9	9	12
Culter dabryi	D	272	33.0	6	7	21
Silver carp	E	967	38.3	30	36	12
Hemiculter leuciscus	F	16	15.0	3	3	5
Mongolian culter	G	259	33.0	5	6	3
Carp	H	899	42.0	11	14	6
Bigmouth grenadier anchovy	I	42	27.5	4	3	10
Pomfret	J	166	24.5	9	7	10
Siniperca chuatsi	K	197	22.5	8	8	14
Pampus argenteus	L	157	25.0	14	4	10
Xenocypris argentea	M	64	19.8	5	3	13
Cultrichthys erythropterus	N	203	31.0	11	6	8
Paracanthobrama guichenoti Bleeker	O	126	23.0	6	4	9

Sample extraction

First, the water samples were transferred to beakers and heated dry in a vacuum drying oven at 90°C for 24 h. After drying and cooling, wet peroxide oxidation (WPO) step was performed to remove natural organic materials (Zobkov and Esiukova 2017). 20 mL of 0.05 M ferrous sulfate solution (AR, Aladdin, China) and 30% hydrogen peroxide solutions (H₂O₂) (Liebezeit and Dubaish 2012) (AR, Aladdin, China) were added for digestion of the organic matter. After digestion and cooling, Sodium chloride was added

to the solution (6.0 g per 20 mL) for density floating. Cover loosely with aluminum foil and let the solid settle overnight. Finally, the supernatant was filtered using a cellulose nitrate filter paper (50 mm Ø, Shanghai Xingya, China) with a pore size of 0.22 µm using a water-circulation multifunction vacuum pump (SHB-III, Bangxi Instrument Technology Co. Ltd.).

After the fish samples were thawed at room temperature, the gastrointestinal tract (abbreviated as GIT from the tip of the esophagus to the excretion opening) and gills were collected and weighed by dissection. The GITs were dissolved with 10% KOH at a ratio of 1:3 (organs to solution) and then sealed them completely (Jaafar et al. 2020). Since the gill rakers in fish gills were arduous to decompose, the gills were dissolved with a 30% H₂O₂ (200 ml/5 g) container and sealed. It was recommended to use a container with a slender body to prevent foam from overflowing. After sonicating for five minutes, the mixture was then shaken for 24 h at 80 rpm on a 60°C shaker. Afterwards, hot filtration was performed to prevent the oil from cooling and clogging the filter membrane. The solution was filtered through a 5 µm nylon filter paper (50 mm Ø, Haining Yibo, China). At last, the filter paper was placed in a covered glass dish and air-dried at room temperature while waiting for microscopic examination.

Observation and identification of MPs

Materials on the filter papers were placed under a Nikon stereomicroscope (Nikon SMZ18, Japan) at a magnification of 10–80 times. Adopt the judgment criteria described in the literature (Cole et al. 2011; Zhao et al. 2014), according to its appearance, shape, and color, it was judged whether it is a microplastic. MPs from each sample were counted and classified according to their shape. Fourier transform infrared spectroscopy (FTIR) was used to further characterize the suspected MPs. The FTIR measurement was performed on an attenuated total reflection Fourier transform infrared spectrometer (Thermos Nicolet IN10 MX, USA). Due to a large number of samples, some typical samples were selected for identification. Among them, 100 samples were randomly selected and analyzed. The samples to be tested were picked up with an ultra-fine stainless steel tweezers, placed on a diamond anvil. The acquisition time of single-point transmission mode when MPs were exposed to infrared radiation in the wavelength range of 4000 – 500 cm⁻¹ once is 3 s. Compared the obtained spectra with a spectral library containing spectra of all common polymers and natural materials on the instrument. Due to the complexity of environmental samples, the infrared spectrum of most microplastic samples does not match the standard spectrum. Spectral analysis accepted matches with a quality index ≥ 0.7.

Quality assurance and quality control

Cotton lab coats and nitrile gloves were worn throughout the experiment and the workbench was wiped 3 times with alcohol and distilled water. All containers used in this experiment were rinsed with deionized water before use and covered with aluminum foil when not in use. The pretreatment process was carried out in a clean fume hood. The filter paper and petri dish were checked under an optical microscope to remove fibers and particles in the non-sample before observing the sample. Then the same pretreatment procedure was used to perform three repeat blank experiments on outdoor samples to eliminate external

interference. No microplastic was observed, and the results showed that the potential microplastic contamination in the laboratory environment was negligible in this study.

Data processing

The MPs abundance units of water and fish samples were the number of particles per liter and the number of particles per individual respectively. The point map of Gehu Lake was drawn by ArcGIS10.2. According to the sampling positions of the eight sites, three parallel samples were set in each sample point. Numerical data were expressed as mean $\pm$ standard error. Origin 2017 was used for drawing.

Results And Discussion

Abundance and distribution of MPs in surface water

In this examination, MPs were detected at all sampling points. A total of 1477 MPs were detected from eight sampling sites. The abundance of MPs in the Gehu Lake Basin ranged from 1.51 to 22.22 n/L is shown in Fig. 2, with an average abundance of 6.33 ± 2.67 n/L. The abundance order of MPs in the eight sampling points is as follows: S1 > S2 > S8 > S4 > S6 > S5 > S3 > S7. The highest level of MPs in Gehu Lake was observed at the S1 site (Taigehekou), the upper reaches of the station is the Taige Canal, which is the main discharge channel and absorbs some MPs from Beijing-Hangzhou Canal. Therefore, river transportation may be a potential source of MPs. The minimum level of MPs was recorded at the S7 site (Beiganhekou). Microplastic abundance was affected by many elements, such as weather, surrounding environment, and anthropogenic(Beer et al. 2018). The abundance of MPs at S2 is second only to S1. To some extent, since the establishment of Changzhou as a city, the tourism industry has flourished. Plastics abandoned by tourists may also cause garbage pollution, which may lead to the accumulation of a large amount of MPs in the river (Eerkes-Medrano et al. 2015). In addition, intense economic activities (such as industrial emissions and land use) can easily lead to poor water quality. There may be a positive correlation between poor water quality and high plastic particle concentration. This will indirectly strengthen the view that the abundance of plastic particles is affected by economic activity(Zhao et al. 2015). Those indicate that the high plastic concentration at S2 may be strongly affected by human activities in urbanized areas, which can explain the abundance of MPs at this point. All of these contributors together may result in the higher microplastic abundance observed in Gehu Lake.

The distribution of MPs in some freshwater environments was summarized. It can be seen from Table.2 that the distribution of MPs is stored in different water bodies. Luo et al. also showed that the spatial distribution of microplastics in water bodies varies across different types of water bodies(Luo et al. 2019). This difference is related to many reasons, including population density and human activities, seasons, hydrological characteristics, and the nature of MPs. For example, the distribution of MPs in the larger Dongting Lake and Hong Lake(Wang et al. 2018), Poyang Lake(Yuan et al. 2019) are mainly due to human activities and developed fisheries. In the same water body, the distribution of MPs is also diverse in different seasons. The abundance of MPs in the Yangtze River Estuary(Zhao et al. 2019) and Nakdong River(Eo et al. 2019) in the rainy season are significantly higher than in other seasons. The difference in

microplastic content in the surface water of Antuã River(Rodrigues et al. 2018) in March and October also indicates that the season is a crucial factor affecting the distribution of MPs. Hydrological characteristics also affect the distribution of MPs. Lakes, reservoirs, and other areas are relatively closed environments, so relatively stable lakes and reservoirs generally contain high levels of MPs, such as the Three Gorges Reservoir in China(Di and Wang 2018) and Taihu Lake(Su et al. 2016). At the same time, the sampling and analysis methods of MPs also affect the MPs Distribution. As an example, the abundance of MPs in the Yangtze River estuary investigated by (Zhao et al. 2019) is much lower than the abundance of MPs in the Yangtze River estuary(Zhao et al. 2014) (more than 25 times lower).

Table. 2. Ranges of microplastic abundance in different inland freshwater areas or estuaries (including this study) in domestic and foreign

Study Areas	Sampling Medium	Abundance	References
Antuã River	Surface water (March)	58–193 n/ m ⁻³	(Rodrigues et al. 2018)
	Surface water (October)	71-1265 n/ m ⁻³	
Nakdong River	Surface water	(293 ± 83)~ (4760 ± 5242) n/ m ⁻³	(Eo et al. 2019)
Yangtze River Estuary	Surface water (February, May, July)	(157.2 ± 75.8) n/m ⁻³	(Zhao et al. 2019)
Yangtze River Estuary	Surface water (July)	(4137.3 ± 2461.5) n/m ⁻³	(Zhao et al. 2014)
Dongting Lake and Hong Lake	Surface water	900–2800 n/ m ⁻³	(Wang et al.2018)
		1250–4650 n/ m ⁻³	
Three Gorges Reservoir	Surface water	1597–12611 n/ m ⁻³	(Di and Wang 2018)
Poyang Lake	Surface water	5–34 n/L	(Yuan et al. 2019)
Taihu Lake	Surface water	3.4–25.8 n/L	(Su et al. 2016)
Gehu Lake	Surface water	1.51–22.22 n/L	This study

Morphological characteristics of MPs in water samples

Based on previous research recommendations (Hidalgo-Ruz et al. 2012), the MPs detected can be divided into four categories: fibers, films, fragments, and particles in Fig. 3. In short, fiber is a long, thin, and smooth linear microplastic, film is a kind of very thin plastic fragment, the fragment is larger plastic fragments broken down into small-sized plastic with jagged edges, the particle is ovoid or disc or

cylindrical. Fibers are among the predominant forms of microplastics found in water bodies ranging from sea beds to remote inland freshwater lakes (Salvador Cesa et al., 2017). Likewise, our study revealed a high proportion of fibers across different sampling sites. Most of the MPs were mainly fibers in the water body of Gehu Lake in Fig. 4a, accounting for about 70%. This result was the same as several previous studies (Su et al. 2016; Zhao et al. 2014) on inland waters in China, which are dominated by fiber. There are more than 3,000 households in the Gehu Lake Basin, surrounded by farmland and numerous factories. With the agriculture and aquaculture industry developing, busy fishing activities could produce many aging fishing gears, such as fishing nets, which also contribute to the dominance of microplastic fibers. Likewise, it was believed that the high fiber content comes from treated laundry wastewater from a nearby wastewater treatment plant (WWTP) (Browne et al. 2011; Wagner et al. 2014). In the current examination, regular pellets (or spheres) and irregular granules were collectively categorized as granules to be well suited for statistical analysis. Fragmented MPs mainly come from the decomposition of plastics produced in daily life, the production and packaging of industrial raw materials, etc. In summary, our results demonstrated that fishery activities and human sewage might be the main sources of microplastic pollution in Gehu Lake.

The identified microplastic particles were classified according to the following 5 dimensions: $<100\text{ }\mu\text{m}$, $100\text{ }\mu\text{m}\sim 500\text{ }\mu\text{m}$, $500\text{ }\mu\text{m}\sim 1000\text{ }\mu\text{m}$, $1000\text{ }\mu\text{m}\sim 2000\text{ }\mu\text{m}$, $\geq 2000\text{ }\mu\text{m}$. $100\text{ }\mu\text{m}\sim 500\text{ }\mu\text{m}$ was the dominant size classification in water samples from Gehu Lake, accounted for about 51.93%. The particle size $<100\text{ }\mu\text{m}$ occupied 24.71%, and the two together account for 76.64%. The dominance of small plastics has been found in many freshwater studies, such as Laurentian Great Lakes, USA (Driedger et al., 2015). In other categories, the proportion of MPs decreases as the size increases, such as 14.96% for those with a particle size between $500\text{ }\mu\text{m}$ and $1000\text{ }\mu\text{m}$, about 5.82% between $1000\text{ }\mu\text{m}\sim 2000\text{ }\mu\text{m}$, about 2.57% for $\geq 2000\text{ }\mu\text{m}$, as shown in Fig. 4b. The result was consistent with the previously reported results, with particles smaller than 2 mm in diameter accounting for the majority (Wang et al. 2017; Zhao et al. 2015; Zhao et al. 2014). For instance, MPs of Jiaojiang, Qujiang, and Minjiang estuary were smaller than 2 mm accounted for $>70\%$ (Zhao et al. 2015), in Wuhan city surface water accounts for $>80\%$ (Wang et al. 2017). These small-diameter particles were similar in size to low-nutrient organisms (such as plankton) and were easily ingested by other organisms in the water.

Classification of MPs based on color. The plastic particles collected in Gehu Lake have rich colors in Fig. 5. In all water samples, transparent was the main color (28.91%), followed by blue (25.12%). The busy fishery may also be an important contributor to these transparent microplastic fibers. The outstanding performance of transparent and colored MPs corresponds to the prevalence of transparent plastics used in plastic products (such as packaging, clothing, and fishing lines) (Zhao et al. 2014). Since Gehu Lake is a scenic spot with a large passenger flow, consumption of colored plastic products (such as food packaging) in daily life will increase the content of plastic waste, and through further decomposition, these wastes may form colored MPs (Wang et al. 2017). These colors may lead to the possibility of plastic ingestion due to the similarity of food, the popularity of these colored plastics in the environment, and the actual preference of the biota for colors (Shaw and Day 1994; Verlis et al. 2013;

Wright et al. 2013). In spite of the different plastic particle characteristics that can be used to speculate on plastic origins, knowledge of the original sources of MPs pollution remains inadequate.

Microplastic pollution in freshwater fish samples

The existence and accumulation of MPs were detected in the freshwater fish samples. A total of 171 suspicious microplastic particles were detected, with the abundance of each was 10.7 items per individual. Previous research (Peters et al. 2017) has shown that the particle content of each fish was observed to be 0.5 to 1.4 particles in six marine fish sampled from the Gulf Coast of Texas, USA. Compared with other freshwater research in China, the density of the MPs in the fish here was similar to that of the crucian carp in Poyang Lake, China (0–18 items per individual) (Yuan et al. 2019). Among the 30 fish detected, the concentration of MPs was the highest in Dachshund, with 15 fibers, 4 fragments, and 2 films in Fig. 6. Among all MPs observed in fish samples, fibers were the most common type of MPs, accounting for 69.59% of all particles. A quintessential example should be cited that a large amount of fibers were observed in the gastrointestinal tract of hairtail fish (Zhu et al. 2019). Fiber was also the main type of microplastic in Khalida Jabeen's research (Jabeen et al. 2017). The most common color was transparent, the same as what was found in water samples. These may be related to the abundance of MPs in its environment because particles with these characteristics are also very abundant in the waters of Gehu Lake. Additionally, the difference in species, feeding, living habits, and sampling locations may also give rise to differences (Sanchez et al. 2014; Silva-Cavalcanti et al. 2017).

As shown in Fig. 7, particles in the size range of 0.1–0.5 mm were dominant in GITs (66.67%) and gills (66.13%) of fish samples, followed by particles of 0.5–1 mm (21.54% in GITs and 19.35% in gills). Large-sized plastics have been frequently recorded in marine fishes (Rummel et al. 2016), but rarely have been recorded in freshwater fishes (Jabeen et al. 2017). Small microplastics have a strong ability to absorb water from hydrophobic organic pollutants (Devriese et al. 2017), which may pose a more serious threat to freshwater organisms. The prime colors of MPs in fish gills were red and blue. However, transparent and blue were the main colors of MPs observed in GITs of fishes, accounting for about 29.23% and 22.56% respectively in Fig. 8. Like water, transparent color was the most common color in GITs of fish, which is consistent with previous research results (Zhu et al. 2019), although blue (Güven et al. 2017; Ory et al. 2017) and black (Bellás et al. 2016) have also been reported as popular colors in other studies. Transparent fibers were exceedingly similar to zooplankton, and they may be more likely to result in fish eating by mistake.

The plastic particles collected from the gastrointestinal tract and gills of fish samples may be closely related to the content of MPs in surface water. However, it is difficult to perform more effective analysis due to insufficient sample size. Gehu Lake is a habitat for the reproduction, feeding, and fattening of important fish in the Taihu Lake Basin. The freshwater fish studied in this subject were the more common and mainly edible fish in the Gehu Basin. Therefore, more in-depth research should focus on the potential risks of MPs to organisms and humans.

Identification of MPs

Conventional MPs can be identified by features such as shape and color, but the smaller the particle size, it was more difficult to identify MPs. Ambiguous characteristics of plastic-like non-plastic and non-plastic-like plastics make it difficult to accurately identify MPs (Song et al. 2015). Therefore, Fourier infrared spectroscopy was used for further confirmation. Of the 100 selected particles, 85 particles were successfully identified as plastics. They were polyester (PES), polypropylene (PP), acrylic acid, polyvinyl chloride (PVC), polyamide (PA), rayon, polyethylene (PE), polyethylene and polyethylene terephthalate (PET), etc (Fig. 9), it fully shows that human production and life near the basin have caused plastic pollution to the river. The remaining particles were non-plastics (15%). In general, the polymer types of the detected MPs were less diverse compared to those collected from Taihu Lake (Su et al. 2016) but similar to those results from the Dongting Lake and the remote lakes in Tibetan Plateau (Hu et al. 2020; Zhang et al. 2019). The results of polymer identification can help trace the original source of plastic fragments (Ballent et al. 2016). PP, PE, and PVC are widely used due to their low cost and easy processing. PP is highly used in fishing tools (Wang et al. 2017). Nylon is widely used in textiles, such as clothes and ropes. It can be inferred that fishing activities and laundry wastewater in residential areas along the river may be potential sources of these MPs. Therefore, in order to determine the priority of measures taken for certain sources of MPs, integrated methods that focus on the source tracking of MPs, such as simulation and isotope tracking should be further explored.

Conclusion

This research was aimed at studying the microplastic pollution to the surface water and fish in Gehu Lake, Changzhou. MPs were found in all surface water and fish samples. The average abundance of MPs in surface water and fish were 6.33 ± 2.67 n/L and 10.7 n/fish respectively. The major type of MPs was fiber in surface water. Transparent was the major color of MPs. A total of 30 fishes were detected, representing 15 species. Ingested microplastic consisted primarily of fibers, mostly blue or transparent. The size of MPs observed in this study was almost 0.1–0.5 mm. PES, Man-made fiber and PP were the dominant types. Our research demonstrated that fishery activities and human domestic sewage jointly affect the pollution characteristics of Gehu Lake MPs, which is likely to result in potential ecological risks and adverse effects for humans. As an important drinking water source and aquaculture base, further long-term and systematic researches are urgently needed to closely monitor the source and transportation of MPs and examine the ecological effects of MPs in the Gehu Lake.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

Competing interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled, “Microplastic pollution characteristic in surface water and freshwater fish of Gehu Lake”.

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Authors' contributions

Ling Zhang: Conceptualization, Data curation, Writing-original draft. **Xia Xu:** Conceptualization, Funding acquisition, Writing-review & editing. **Yingang Xue:** Project administration, Supervision. **Yu Gao:** Data curation, Investigation. **Liping Wang:** Conceptualization, Resources. **Mingguo Peng:** Conceptualization, Resources. **Shanqing Jiang:** Project administration, Writing-review & editing. **Qiuya Zhang:** Conceptualization, Validation.

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Figures

Figure 1

Geographic position of sampling sites

Figure 2

The abundance of microplastics in surface water of Gehu Lake. S1–S8 of the X-axis represent the sampling sites.

Figure 3

Types of microplastics in the surface water from Gehu Lake: (a) fiber, (b) film, (c) fragment, (d) pellet

Figure 4

Categorization of microplastic particles by shape (a), and size (b) in surface water.

Figure 5

The different colors of microplastics in surface water of Gehu Lake.

Figure 6

The abundance of microplastics in fish from Gehu Lake. A–O of the X-axis represent the different fish samples.

Figure 7

The percentage of microplastics size in GITs and Gills of fishes.

Figure 8

The percentage of microplastics colors in GITs and Gills of fishes.

Figure 9

FTIR spectra of the selected microplastic particles. The percentage similarity of the spectra with those of the standards is shown in parentheses.

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