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Microplastics in surface waters of Dongting Lake and Hong Lake, China

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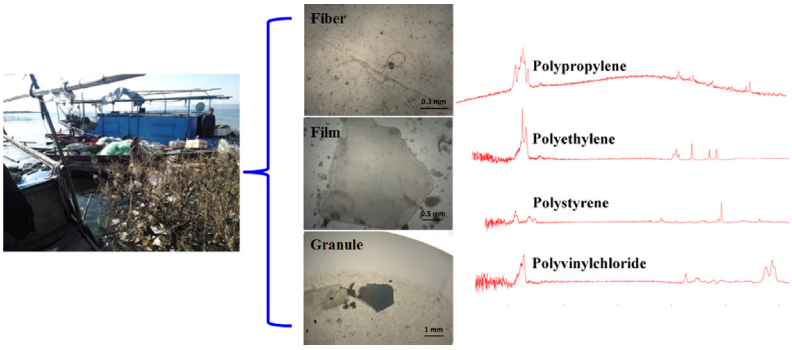
HIGHLIGHTS

- Microplastics pollution was studied in surface water of Dongting Lake and Hong Lake.
- Fishery activity was an important source of microplastics in both lakes.
- Particles with a size of <2 mm dominated the microplastic samples.
- Fibrous microplastics occupied the majority in both lakes.
- Hong Lake had higher microplastic abundance than Dongting Lake.

GRAPHICAL ABSTRACT



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ABSTRACT

Microplastics pollution is an environmental issue of increasing concern. Much work has been done on the microplastics pollution in the marine environments. Although freshwaters are potential sources and transport pathways of plastic debris to the oceans, there is a lack of knowledge regarding the presence of microplastics in freshwater systems, especially in China, the world's largest producer of plastics. This study investigated the occurrence and properties of microplastics in surface waters of two important lakes in the middle reaches of the Yangtze River. The concentration ranges of microplastics in Dongting Lake and Hong Lake were 900–2800 and 1250–4650 n/m^3, respectively. Fiber was the dominant shape. Colored items occupied the majority. Particles with a size of <330 μm comprised >20% of total microplastics collected in both lakes. Most of the selected particles were identified as plastics, with polyethylene (PE) and polypropylene (PP) being the major components. This study can provide valuable reference for better understanding the microplastics pollution in inland freshwater ecosystems.

1. Introduction

The occurrence and distribution of microplastics (<5 mm) have been widely reported in the marine environments and recognized as an emerging concern that may cause adverse effects to the health of marine ecosystems (Andrady, 2011; Cole et al., 2011; Seltenrich, 2015; Galloway and Lewis, 2016). Although freshwaters, particularly rivers, are potential sources and transport pathways of microplastics to the oceans (Lebreton et al., 2017; Schmidt et al., 2017; Hendrickson et al., 2018), knowledge about microplastics pollution is still comparatively limited in these environmental compartments. In the literature on freshwater systems, microplastics were not documented until the 21st century (Moore et al., 2011; Eerkes-Medrano et al., 2015; Horton et al., 2017). Preliminary studies reported that microplastics are ubiquitously present in various freshwater habits around the globe, including

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beaches, waters and sediments of lakes, rivers and estuaries (Zbyszewski and Corcoran, 2011; Wagner et al., 2014; Zhang et al., 2015; Zhao et al., 2015; Zhang et al., 2016; Lebreton et al., 2017; Schmidt et al., 2017; Wang et al., 2017a). In addition, microplastics pollution in many freshwaters is comparable or more serious than that in the marine waters (Wu et al., 2018). The extensive distribution of these small-sized plastic particles in aquatic environments may induce harmful impacts to the aquatic organisms, because the size range of microplastics covers the preferred particle size ingested by some aquatic animals at lower trophic levels of the food chain, which makes it possible for transfer of microplastics themselves and the associated chemicals into the food-web (Seltenrich, 2015; Galloway and Lewis, 2016). Laboratory and field investigations showed that both marine and freshwater animals can ingest microplastics (Boerger et al., 2010; Cole et al., 2013; Lusher et al., 2013; Sanchez et al., 2014; Biginagwa et al., 2016; Silva-Cavalcanti et al., 2017). Given the very limited data on the microplastics pollution in freshwater systems, it is urgently essential to better characterize the abundance, distribution, and potential sources of microplastics in freshwaters in order to comprehensively evaluate the risk of microplastics and develop effective measures to address this issue.

China is the largest producer of both plastics and plastic wastes all over the world (Jambeck et al., 2015; PlasticsEurope, 2016). Large proportions of these plastic wastes are mismanaged and eventually enter the aquatic environments where they evolve into microplastics via progressive fragmentation (Jambeck et al., 2015; Horton et al., 2017; Wu et al., 2018). As far as we know, up to now only a handful of studies focused on the microplastics pollution in inland freshwater systems of China, which were carried out in the Three Gorges Reservoir (Zhang et al., 2015), Taihu Lake (Su et al., 2016), Tibet Plateau lakes (Zhang et al., 2016), Wuhan urban lakes (Wang et al., 2017a), and Xiangxi Bay (Zhang et al., 2017a). Especially, the abundance of microplastics in the surface waters of the Three Gorges Reservoir was reported to be up to 1.36×10^7 items per square kilometer, which is the highest microplastics concentration ever reported in the literature (Zhang et al., 2015). In Wuhan urban lakes, microplastics were detected with a concentration range from 1660 ± 639.1 to 8925 ± 1591 items per cubic meter (Wang et al., 2017a). These preliminary studies demonstrated the wide occurrence of microplastics in many inland lakes and rivers of China and called for more efforts to better understand the pollution status of microplastics in its freshwater systems.

Dongting Lake and Hong Lake are both important lakes in the middle reaches of the Yangtze River. They play an important role in flood regulation, fishery, tourism, and water supply for local agriculture and industry. However, large watershed population and intensive anthropogenic activities have caused increasing pollutions in the two lakes (Yang et al., 2015; Wang et al., 2017b; Zhang et al., 2017b). In the present study, we screened the abundance and properties of suspended microplastics in surface waters of both Dongting Lake and Hong Lake. These data may help to fill the knowledge gaps regarding microplastics pollution in China's freshwater environments, and provide guidance for the future monitoring works and establishment of some protective measures against plastics pollution in the two lakes.

2. Materials and method

2.1. Study area and sampling method

Dongting Lake (N 28°30′–30°20′, E 111°40′–113°10′), located on the south bank of the middle reaches of the Yangtze River, is the second largest freshwater lake in China, covering an average water surface area of 2.5×10^3 km^2 (Fig. 1). The mean and maximum depths of Dongting Lake are 6.39 m and 18.67 m, respectively. Dongting Lake is connected to the Yangtze River by four distributary channels. Shipping, aquaculture and tourism are the main anthropogenic activities in Dongting Lake. As the seventh largest freshwater lake in China, Hong Lake (N 29°39′–30°12′; E 113°7′–114°05′) is situated on the north bank of the middle reaches of the Yangtze River, covering a surface area of 413 km^2 (Fig. 1). Hong Lake is a typical shallow lake (average depth of 1.5 m) and has been isolated from the Yangtze River since 1950s by hydraulic projects. It is listed in Ramsar Convention since 2008. Aquaculture is the major human activity in this lake.

Sampling work was conducted in September 2017. The number of surface-water samples collected in Dongting Lake and Hong Lake was 30 and 20, respectively. A total of 20 l of bulk surface water (0–20 cm in depth) was collected in twice (10 l of water per time) at each sampling site using a 12 V DC Teflon pump, and filtered through a stainless steel sieve with a mesh size of 50-μm (Zhao et al., 2015; Wang et al., 2017a). The residues were rinsed into a glass bottle with distilled water and preserved in the 4% formalin solution. The geographical coordinates of sampling sites were recorded with the global position system (GPS) (Table S1).

2.2. Sample analysis

In the laboratory, in order to digest the biological materials, samples were pretreated with 30% H_2O_2 at room temperature in the dark for 48 h in covered glass bottles, and then passed through the 0.45-μm glass microfiber filter papers (GF/F, 47 mm Ø, Whatman) using a vacuum pump. After that, the filter paper was transferred into a clean glass petri dish and examined carefully under a M165 FC dissecting microscope (up to ×160 magnification) (Leica, Germany). Particles were identified as microplastics according to the selection criteria described by Hidalgo-Ruz et al. (2012)). Microplastics were enumerated by categorizing them into different classes based on their visual characteristics (size, shape and color). The size of fibers was measured according to

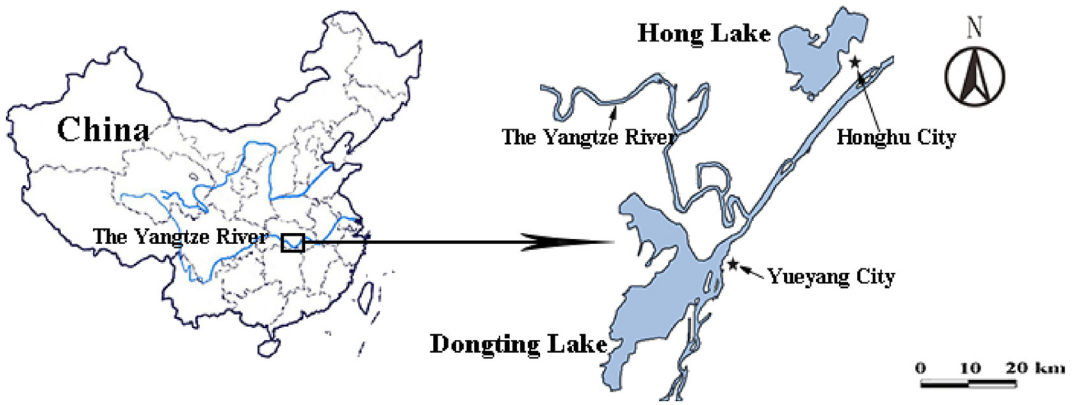

Fig. 1. Geographic location of Dongting Lake and Hong Lake.