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Status and characteristics of microplastic pollution in Chinese freshwater environment

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Abstract. The system sorts out the distribution characteristics of microplastics, the toxic effect of biology, and the interaction with other pollutants. Micro -plastic is still a very difficult to control pollutant. Micro -plastic has a threat to the environment. At present, the control of micro -plastic pollution is very small, and it is urgent to strengthen supervision in this area.

Keywords: Microplastic, Pollution, China.

1. What are microplastics and the harm they do to the world

Plastics are one of the most widely used materials in the world's industrial industries, and their production has grown rapidly in recent years, with global plastic production approaching 360 million tons in 2018 [1]. Microplastics (MPs) are a generic term for a class of heterogeneously mixed plastics with a diameter of less than 5 mm and a new type of persistent pollutant. Common types of microplastics in the environment mainly include polypropylene (PP), polyethylene (PE), polystyrene (PS), polyethylene terephthalate (PET), polyamide (PA), polyvinyl chloride (PVC), polyurethane (PU), polymethyl methacrylate (PMMA), polycarbonate (PC), and nylon (Rayon). Microplastics can be divided into primary microplastics and secondary microplastics. Primary microplastics are widely used as exfoliating cosmetic additives, industrial abrasives, sandblasting media, etc. These microplastics usually enter wastewater treatment plants through the domestic wastewater collection system, and because of their size, they are difficult to settle or remove, making wastewater treatment plants an important aggregation area for land-based microplastics, and the subsequent discharge of treated wastewater will eventually result in some microplastics entering the marine system. Secondary microplastics are formed by the gradual fragmentation (e.g., thermochemical cracking, photo-oxidative cracking, ozone-induced cracking, and cracking) of large pieces of plastics present in the ocean, and are the main source of microplastics in the ocean. Microplastic pollution was first found in the oceans [2]. The research in the marine environment is relatively mature in the world today, and the research on microplastics in the freshwater environment started later. As shown in Table 1, domestic and international studies have also found the presence of microplastics in inland water bodies including Three Gorges Reservoir, Dongting Lake, Taihu Lake, Rhine River, Danube River, and the Great Lakes of North America, and the concentration of microplastics in some freshwater environments is much higher than that in marine systems [3].

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Table 1. Particle size and abundance of floating microplastics in water environment in parts of China [4].

Region	Particle size	Abundance
East China Sea Coast	0.5~5 mm	(0.167±0.138) particles·m-3
North Yellow Sea	<1 mm	(381.5±197.4) particles·m-3
Bohai Sea	>330 μm	(0.33±0.34) particles·m-3
Dongting Lake	>330 μm	1191.7 particles·m-3
Hong Lake	>330 μm	2282.5 particles·m-3
Yangtze River Estuary	(0.90±0.74) mm	(4137.3±2461.5) particles·m-3
Taihu Lake	>5 μm	(0.01~6.8) X10-6 particles·m-3
Han River	<2 mm	(1328±511.28) particles·m-3
Three Gorges Reservoir	<5 mm	1597~12611 particles·m-3
Minjiang River	>330 μm	(1245.8±531.5) particles·m-3
Jiaojiang River	>330 μm	(955.6±848.7) particles·m-3
Oujiang River	>330 μm	(680.0±384.6) particles·m-3

2. Distribution of microplastics, Bio-toxic effects, and interactions with other pollutants

2.1. Distribution characteristics of microplastics

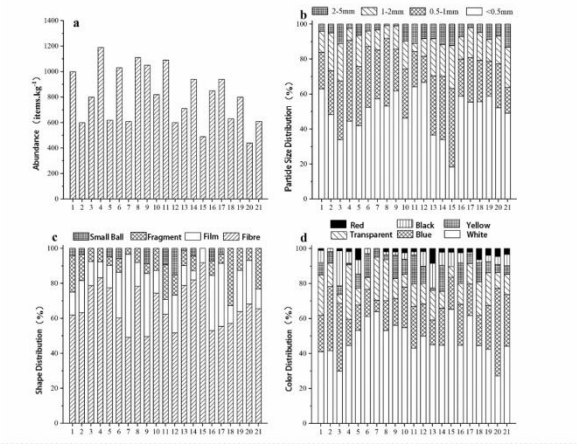


Figure 1. Microplastic abundance (a) size (b) shape (c) and color distribution (d) in the sediment of Dali River.

The abundance and characteristics of microplastics in the sedimentary sediment of the Dali River are shown in Fig. 1. Microplastics were detected in all sedimentary sediment samples, with the average value of 806 units-kg-1 in the range of 440-1190 units-kg-1 (Fig. 1a). As shown in Figure 1b, microplastics with particle size <0.5 mm were the most abundant in the sediment, reaching (50.12%), followed by 0.5-1 mm (28.27%), 1-2 mm (14.83%) and 2-5 mm (6.78%), i.e., the proportion of microplastics decreased as the particle size increased. In addition, a high proportion of small size (<1 mm) microplastics was found in most studies, such as Weihe and Taihu [5]. A large amount of small-sized microplastics can be attributed to the fragmentation and degradation of large plastic debris by mechanical wear, photo-oxidation, and biological effects. In addition, the direct anthropogenic

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discharge of small-size microplastics is a potential source of small-size microplastics in the environment.

In other natural water bodies, such as the average abundance of microplastics in surface seawater in the Bohai Sea and the northern Yellow Sea, the abundance of microplastics in surface seawater is high. Microplastic pollution in freshwater systems of rivers and lakes is heterogeneous, and the abundance of microplastics is higher in waters with high human activities. The estuaries of Jiaojiang, Oujiang, and Minjiang rivers and Taihu Lake in China are contaminated with microplastics to different degrees [6].

Depending on their composition, density, and shape, microplastics can exist at various depths in the ocean, including floating on the surface, immersed in the sea, and even sinking to the bottom. Low-density microplastics are mainly found in surface seawater, while the attachment of organisms causes floating microplastics to sink [6].

2.2. Bio-toxic effects of microplastics

2.2.1. Microalgae. Studies have shown that polyvinyl chloride microplastics, with an average diameter of 1000 μm, have a significant inhibitory effect on the growth of microalgae, with a maximum growth inhibition rate of 39.7% after 96h. High concentrations (50 mg-L-1) of polyvinyl chloride microplastics also hurt algal photosynthesis, with chlorophyll content and photosynthetic efficiency decreasing under treatment. Physisorption pairs on nano-polystyrene plastic beads of Chlorella Vulgaris and Chlamydomonas graminearum were studied. The adsorption of plastic beads impeded algal photosynthesis through physical blockage of light and airflow by nanoparticles. Reactive oxygen measurements further showed that plastic adsorption promoted the production of reactive oxygen species in the algae [7].

2.2.2. Fish. The current effects of microplastics on the physiological activities of fish are mainly related to reproduction, immunity, growth, metabolism, and behavior. Previously, some articles reviewed the reproductive effects of microplastics on aquatic organisms (shellfish, fish, etc.) and found that the effects of microplastic exposure on aquatic reproduction varied by species, but most of the findings indicated that germ cell and oocyte quality, reproductive capacity, sperm swimming speed, and offspring quality of aquatic organisms were significantly reduced after microplastic exposure [8].

2.2.3. Zooplankton. Microplastics reduce the feeding ability of zooplankton and reduce energy intake, which in turn affects the redistribution of energy to certain key life traits (e.g., growth and development and reproduction). The effects of microplastics on zooplankton can be divided into physical damage and chemical effects. The former is mainly related to the blockage of ingested microplastics in the digestive tract, leading to reduced feeding, malnutrition, and even death of zooplankton: while the latter is related to the chemical nature of microplastics. The main mechanism behind the toxicity of microplastics is related to the generation of oxidative stress, which in turn comes from the inflammatory response of zooplankton in response to microplastics [9].

2.3. Interaction of microplastics with other pollutants

The hydrophobic surface of microplastics can provide a good living environment for microorganisms, but the extracellular secretions, cell growth, structure, and function of microorganisms can change under the combined effect of microplastics and organic pollutants. The presence of microplastics may enhance, inhibit or not affect the toxic effects of organic pollutants on microorganisms, which is related to the adsorption capacity of microplastics and may also be due to the differences in the tolerance level of different microorganisms to microplastic stress. In the future, we need to further investigate the toxicological effects and mechanisms of microplastic-organic pollutants on microorganisms from the molecular level by combining genomics, proteomics, and metabolomics [10].

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However, whether the presence of microplastics enhances or attenuates the toxicity of organic pollutants in the environment compared with the single toxic effect of organic pollutants and the mechanisms of these effects are still controversial. However, it is still controversial whether the presence of microplastics enhances or diminishes the toxicity of organic pollutants in the environment compared with the single toxic effect of organic pollutants, and the mechanism of interaction between microplastics, organic pollutants, and living organisms can be explored [10].

3. Research Prospects

(1) Develop countermeasures for microplastic pollution control: the amount of microplastics in the environment is increasing, and in the future, laws, and regulations on microplastic pollution control should be improved, and legislative investigations to restrict the production and use of microplastic products should be carried out as soon as possible, and corresponding alternative products should be developed to reduce the use of plastics.

(2) Develop different programs to measure the content of microplastics in the water environment according to the different waters. Multiple samples are taken and the experiment is repeated to reduce the experimental error.

4. Conclusion

In different water environments, microplastics will have a different distribution in different waters and will have different toxic effects on different kinds of organisms. We should go to use different methods to manage the pollution of microplastics in water bodies to reduce the toxicity to organisms and avoid interacting with other pollutants to produce more drastic effects on organisms.

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