



## Viewpoint

## Micro(nano)plastics: Unignorable vectors for organisms

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## ABSTRACT

Micro(nano)plastics, as emerging contaminants, have attracted worldwide attention. Nowadays, the environmental distribution, sources, and analysis methods and technologies of micro(nano)plastics have been well studied and recognized. Nevertheless, the role of micro(nano)plastic particles as vectors for attaching organisms is not fully understood. In this paper, the role of micro(nano)plastics as vectors, and their potential effects on the ecology are introduced. Micro(nano)plastics could 1) accelerate the diffusion of organisms in the environment, which may result in biological invasion; 2) increase the gene exchange between attached biofilm communities, causing the transfer of pathogenic and antibiotic resistance genes; 3) enhance the rate of energy, material and information flow in the environment. Accordingly, the role of microplastics as vectors for organisms should be further evaluated in the future research.

## 1. Introduction

Plastic pollution, a new type of emerging environmental pollution, has aroused increasing focuses in recent years (Law and Thompson, 2014). Plastic wastes are chemically stable, corrosion-resistant and difficult for biodegradation, which may exist for hundreds to thousands of years, causing continuous accumulation in the environment (Barnes et al., 2009; Hu et al., 2019). Under the condition of sunlight exposure, weathering, erosion and immersion, large plastics would be decomposed into small species (Auta et al., 2017). The release of plastic particles added to daily personal care products (including toothpaste, detergent, scrub and facial cleanser is also an important source of microplastic (Fendall and Sewell, 2009). When the particle sizes of plastic species have less than 5 mm, they are defined as microplastics (Thompson et al., 2004). Microplastics can be further broken down into nanoplastics in natural environments (Mattsson et al., 2015).

Microplastics could be easily and mistakenly eaten by zooplankton (Desforges et al., 2014), benthic animals (Boerger et al., 2010) and filter-feeding animals (Germanov et al., 2018) due to the small particle size and widespread distribution in the aquatic environment (Anderson et al., 2017; Kanhai et al., 2018; Schmidt et al., 2018; Wen et al., 2018; Xiong et al., 2018), even in polar regions (Obbard, 2018), which would affect the absorption of organisms for nutrients to endanger their growth and reproduction (Wright et al., 2013). Evidences suggested

that microplastics can be accumulated in organisms (Li et al., 2015). Meanwhile, microplastics would also induce liver inflammation and change the metabolic pathways to organisms' liver (Lu et al., 2016). When the size of microplastics reaches to the nanometer level, forming nanoplastics, its ability to invade the organism is further enhanced. Evidence showed that nanoplastics could penetrate the blood-brain barrier and eventually enter the brain groups (Chen et al., 2017; Kashiwada, 2006), which may have profound potential impacts on organisms.

Micro(nano)plastics, as a kind of particulate matter, can provide an attachment substrate for microorganisms, zooplankton, phytoplankton and protozoans to form a microbial community (Curren and Leong, 2018; Miao et al., 2019). Besides, due to the widespread distribution and constant drifting along with seawater, the microbial community may cause serious marine ecological effects such as the spread of pathogenic bacteria and resistant genes, biological invasion and the production of new species. As vectors of organisms, micro(nano)plastics are gradually being concerned to global scientists. The co-ecological effect of micro(nano)plastics and biology should be a hot issue in the further of micro(nano)plastic study. The main objective of this paper is to provide a summary of different function of micro(nano)plastics as vectors and their potential co-ecological effects of the micro(nano)plastics and biology on the environment, including aggregation, diffusion, and biological invasion.

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## 2. Vectors for microorganisms

Micro(nano)plastics can adsorb organic and inorganic nutrients from water environment to attract the bacteria, viruses and other microorganisms to adhere on their surfaces (Frere et al., 2018). Microorganisms aggregate here to obtain more nutrients to improve the ability of bacterial energy. Micro(nano)plastics can also provide relatively stable habitats, helping microorganisms to resist environmental stresses and enhance microbial diffusivity (Oberbeckmann et al., 2015a). This function of micro(nano)plastics could enhance material circulation and energy transfer along the food chain, and may also be one of the reasons why microorganisms tend to adhere themselves to the micro(nano)plastic surface. Herein, we provide three aspects of evidence to introduce vector function of micro(nano)plastics for microorganisms.

Firstly, micro(nano)plastics can accelerate the diffusion of microorganisms in the environment. Micro(nano)plastics have strong floatability and mobility (Khatmullina et al., 2017), and can support the drift and long-term existence of surface microorganisms in the water. Micro(nano)plastics can diffuse the microbial community into a new habitat together under the ocean currents (Keswani et al., 2016). For example, several coral pathogens have been found in 95 plastics and debris from the Eastern Pacific Ocean (Goldstein et al., 2014). Additionally, higher levels of potential human pathogens frequently were observed in micro(nano)plastics from North Sea and North Atlantic furtherly (Kirstein et al., 2016). The abundance of pathogens is high on the micro(nano)plastics, which may serve as vectors for diffusion of certain bacterial communities. Due to the suitable conditions, a large number of alien species, especially toxic and pathogenic bacteria, may invade new habitats and multiply quickly in a short time. It will change and harm the local community structure and result in biological invasion, which may affect the safety of water quality and pose a potential threat to human health (Kirkpatrick et al., 2004; Kirstein et al., 2016; Zettler et al., 2013).

Secondly, micro(nano)plastics can increase the gene exchange between attached between biofilm communities, or between communities on biofilms and surrounding environment (Arias-Andres et al., 2018). As a result of the strong variability of bacterial genes, gene exchange between microorganism communities can occur through horizontal gene transfer in the environment (Broszat and Grohmann, 2014; Madsen et al., 2012; Molin and Tolkernielsen, 2003). Accordingly, new bacteria may be produced during the gene exchange. In particular, pathogenic and antibiotic resistance bacteria contain abundant pathogenic and antibiotic resistance genes, which may be transferred by multi pathways between communities on biofilms. It will cause outbreak of pathogenic and antibiotic resistant genes and lead to large-scale infection events in the environment.

Thirdly, micro(nano)plastics may speed up the spread of the antibiotic resistance genes and bacteria in the environment. Resistant gene and bacteria are often found in downstream waters of medical wastewater treatment plants (Karkman et al., 2017). Once a large number of resistance genes and bacteria enter the ocean system, it may induce the horizontal transfer of resistance genes between communities or the surrounding environment. The existence of micro(nano)plastics may enhance the transportation of antibiotic resistance genes and bacteria due to the strong floatability and mobility of micro(nano)plastics. Antibiotic resistance genes and bacteria may be transferred to different areas. The exchange of antibiotic resistance genes between communities or the surrounding environment and the existence of antibiotic resistance bacteria may cause huge uncontrollable disasters (Bloom et al., 2017; Long et al., 2015).

Overall, micro(nano)plastics can provide an attachment substrate for microorganisms to form a microbial community. Micro(nano)plastics not only act as vectors of microorganisms diffusion, but as vectors of gene exchange and transfer. However, the ecological effects of microplastics as microorganism vectors are not yet fully unknown.

Therefore, it is necessary to investigate the abundance and species of microorganisms in micro(nano)plastics, to explore the diffusion mechanism of micro(nano)plastics as vectors, and to evaluate the ecological and environmental risks of micro(nano)plastics in further studies.

## 3. Vectors for planktons and animals

Compared with water body, micro(nano)plastics may be rich in nutrients due to the sorption of organic and inorganic matters from water environment. Micro(nano)plastics can provide relatively stable habitats for planktons in the marine environment (Carpenter and Smith, 1972; Oberbeckmann et al., 2015b). Planktons attached on micro(nano)plastic surface can obtain more foods, which may be one of the reasons why planktons are attracted to be attached on micro(nano)plastics. For predators, micro(nano)plastic particles rich in biofilms may be sufficient food sources for aquatic organisms. Therefore, we presume that not only the predation efficiency for organisms can be improved by feeding on micro(nano)plastics, but the rate of energy, material and information flow in the aquatic environment can be enhanced. We provide here three aspects of evidence to introduce our conjectures.

The first is that micro(nano)plastic particles provide more foods to predators. A lot of organisms, such as bacteria, planktons and microfauna, aggregate on the surface of micro(nano)plastics to form biofilms. Under the natural conditions, predators would preferentially select foods with more energy and nutrient to improve predatory efficiency (Steer et al., 2017; Vendel et al., 2017). The competition of zooplanktons and fish larvae is abnormally fierce in the marine environment, especially in oligotrophic waters (Carlson et al., 2002; Dodson, 1974). Therefore, micro(nano)plastics from the eutrophic waters to oligotrophic waters may carry more foods, thereby increasing the ingestion of micro(nano)plastics by zooplanktons and fish larvae and increasing their predation efficiency.

The second is that micro(nano)plastics may enhance the rate of energy, material and information flow in the aquatic environment. Micro(nano)plastics can provide abundant and comprehensive nutrients for predators to satisfy their demands. Protozoa can feed on bacteria and planktons, and high predators, such as fishes, feed on protozoa. Fishes not only can obtain a variety of nutrients from micro(nano)plastics and planktons, but gain more nutrients from protozoa. This process is called trophic upgrading, which improves the flow of energy, material and information of the micro-ecosystem along the food chain (Breteler et al., 1999; Hiltunen et al., 2017). Micro(nano)plastics aggregate organisms of different trophic levels and accelerate the trophic upgrading among them. Thus, the rate of energy, material and information flow may be accordingly enhanced in the aquatic environment through the trophic upgrading.

The third is that micro(nano)plastic particles possess similar activity characteristics with marine snow (Porter et al., 2018). It was confirmed that marine snow can provide habitats for microbial communities and also is a highly active center of photosynthesis, decomposition and nutrient regeneration (Alldredge and Silver, 1988). Many communities of zooplankton have been found in marine snow in sea waters (Bochdansky et al., 2016; Ivancic et al., 2018; Porter et al., 2018). Organisms tend to gather on marine snow because marine snow can provide abundant nutrients for them (Montgomery et al., 2016; Tansel, 2017). Owing to similar characteristics with marine snow (Porter et al., 2018), there is an inference that biofilms on micro(nano)plastics can also attract organisms to adhere, improve the predatory efficiency and enhance the rate of energy, material and information flow in the aquatic environment.

In short, micro(nano)plastic particles may have great potential to enhance the predation efficiency. However, toxic and harmful organisms may exist on micro(nano)plastic surface (Oberbeckmann et al., 2015a). These organisms and micro(nano)plastics themselves have adverse effects on the survival, growth and reproduction to organisms (Boerger et al., 2010; Cedervall et al., 2012). When predators emerge

different degrees of damage causing energy intake reduction, they need to ingest more particles. Such a phenomenon might result in great damage to marine ecosystem. However, it is not yet fully understood that whether micro(nano)plastics rich in biofilms are preferentially eaten by marine predators. Consequently, relevant researches should be performed to understand and explore the relationship between the intake rate and the abundant existence of micro(nano)plastics and nutrient types.

#### 4. Conclusion and recommendation

Micro(nano)plastics as organism vectors may accelerate the diffusion of organisms, improve the gene exchange among different species, speed up the migration of resistant bacteria and genes, inducing uncontrollable transmission of resistant bacteria and genes in the environment. Micro(nano)plastics may also cause biological invasion and serious ecological disasters due to the spread of harmful algae and pathogenic bacteria. Additionally, micro(nano)plastics may enhance the rate of energy, material and information flow of the aquatic ecosystem, but may result in damage to aquatic ecosystem. The research of micro(nano)plastics as vectors for organisms is a new topic. Many conclusions are still in the speculative stage, and there are barely scientific and sufficient information to confirm. Consequently, some experiments and studies should be carried out in the future:

- (1) Identifying the main microbial communities, species composition in different water environments, and effects of microbial habitat on micro(nano)plastics.
- (2) Exploring the adsorption mechanism of organisms on micro(nano)plastic vectors, the probability of gene exchange among species, the advantages of biological community structure and function, and the diffusion mechanism of pathogenic organisms attaching on micro(nano)plastics.
- (3) Analyzing the impact of community accumulation in micro(nano)plastics on predators, and the selectivity of predators to foods at different environmental conditions.
- (4) Establishing the ecological health risk assessment system of micro(nano)plastic pollution.

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