Occurrence and Characteristics of Microplastics Pollution in Different Types of Urban Runoff

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***Abstract*—Recently, plastic debris and microplastics pollution have been found widely in marine and freshwater systems. As one of the major sources, microplastics distribution and pollution in urban surface runoff is still unknown. This study aimed at quantifying and analyzing the occurrence and characteristics of microplastics in different urban runoff by simulating rainwater runoff to scour three types urban surfaces. The results showed that microplastics pollution occur in residential areas, parking lots and urban cement pavements with the average concentrations of microplastics, 145 particle/m^3, 3 particle/m^3 and 1 particle/m^3, respectively. The cumulative intensities of parking lots and urban cement pavements are much lower than residential roads, which might be highly due to frequently used plastics around these areas. Meanwhile, according to the calculation in this study, microplastics pollution in urban surface runoff may play a significant role in the contribution to that pollution in subsequent rivers and coastal oceans.**

***Keywords*—Occurrence; Characteristics; Microplastics; Urban runoff.**

I. Introduction

Microplastics have recently attracted widespread attention, with the increasing demand of packing materials, microbeads and cosmetics, plastics production has increased dramatically up to 311 million tons in 2015 during the past six decades[10]. Due to their transportation and persistence, microplastics can negatively impact aquatic and marine ecosystems, even transferred into the food chains to do harm to higher trophic organisms[2]. Meanwhile, microplastics are often hydrophobic, they have the tendency to absorb persistent organic pollutants (POPs), such as PBDEs, endocrine disrupting compounds (EDCs), pharmaceuticals and personal care products (PPCPs), along with other persistent organic pollutants[5]. Despite the fact that the concentrations of PBDEs, EDCs and PPCPs are so low, they can be interacted with microplastics and enriched on the surface of microplastic debris, which consequently increase the ecotoxicity of microplastics pollution in aqueous media[5][11]. To achieve a cleaner greener aquatic system, “single-use plastics rejection” has been the worldwide theme on 2018 World Environment Day.

Microplastics, commonly made of polyethene (PE), polystyrene (PS), polupropylene (PP), polyethylene terephthalate (PET), are defined as plastics which are smaller than 5 mm at any dimensions[14]. Microplastics are commonly classified into primary microplastics and secondary microplastics. Primary microplastics refer to plastic granular industrial products discharged into the water environment through rivers, sewage treatment plants, such as cosmetics have microbeads. And secondary microplastics are plastic particles formed by the fragmentation and degradation of large plastics waste through physical, chemical and biological processes [3].

Many researchers found that microplastics fragmented by the plastics debris occurred in worldwide aquatic and marine systems, such as the Pacific Ocean, the Atlantic Ocean, European Seas and the Mediterranean Sea [4]. In marine environments, microplastics have various concentrations in different distributions. The concentration of microplastics in the Chinese Bohai Sea was 63–201 items/kg [15], and 0–144 particles/m^3 was detected in the Yangtze Estuary and East China Sea[16]. In the Vancouver Island of Canada, the microplastics count reached up to 279 particles/m^3 [7]. Another case found that in the Geoje Island of South Korea, the amount of microplastics can reach 16000 particles/m^3 [13]. In additional, Microplastics are detected 0.90 ± 0.10 microplastics/g in the Mediterranean Sea [1]. Moreover, microplastics were found in freshwater sysyems, in the Laurentian Great Lake with the conentration of 43,000 particles/km2 to 466,000 particles/km2 [8]. These previous studies showed that microplastics posed a significant threat to marine and freshwater ecosystems.

However, as one of the major sources of oceans and rivers, contaminants in urban runoff may notably contribute to their pollution in subsequent marine and freshwater environment, like the non-point source pollution emissions into lakes or oceans resulting in eutrophication[12]. These pollutants accumulated in urban surface may be washed into runoff after rainfall events, which is a source of the pollution in river and ocean systems. Therefore, microplastics in surface runoff may have the potential to impact the marine pollution. There is a need to investigate the significant occurrence and characteristics of microplastics in different urban runoff.

This study quantified and analyzed the microplastics pollution in different urban runoff by simulating rainwater runoff to scour three types urban surfaces, including residential areas, parking lots and urban cement pavements. The aims of this study are to investigate the occurrence and characteristic of microplastics in different urban runoff and provide some reference for microplastics source of marine and freshwater environment.

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II. Materials and Methods

A. Experiment site

Sampling site in this study was located at the campus of Luoyang Institute of Science and Technology, China, in the middle and lower streams of the Yellow River with the temperate monsoon climate. This study selected three sampling points with major urban surface characteristics, including residential roads, parking lots and cement pavements.

B. Experimental setup

The samples of microplastics in surface runoff were collected by simulated runoff scouring events in January, 2019. The simulated rainfall was prepared by 24-h naturally aerated tap water. During each scouring event, 1.5 L simulated runoff was used for washing the sampling surface and then water samples were collected into a 500 mL glass bottle. At the same sampling point, three duplicates were taken to collect the samples and nine samples were stored in ice box before analysis.

C. Data analysis

In this study, the pretreatment of samples includes two parts: first is density separation, that is, mixing 500 mL saturated NaCl solution with 500 mL sample in 1 L glass beaker, then shaking 60 s and settling for 15 min. The dry filter paper was weighed as M_1 by the analytical balance. Then the dry filter paper was put into the SHZ-DⅢ filter, washed by deionized water, and poured into the mixture of sample and saturated NaCl solution for filtration. After the filtration, the filter paper was taken out and observed by the COIC XSZ-4G biomicroscope to count the number of microplastics by visual sorting. Finally, the filter paper with microplastics was placed at ambient temperature about 20℃ until it was completely dried. Then, it was weighed as M_2 by the analytical balance. The formula for calculating the quality of microplastics was obtained as follows: $M_{(MP)}=M_2-M_1$.

TABLE I: Mass weight, concentrations and surface material

Site	Particles/m^3	$M_{(MP)}/g \cdot L^{-1}$	Surface material	Site characteristics
Residential roads	144.6667	0.157567	Brick	More domestic garbage, more people live here
Parking lots	3.33333	0.110533	Asphalt	Vehicle parking space, fewer people
Cement pavement	1.33333	0.1029	Cement	Main roads, more vehicles

III. Results and discussions

A. Occurrence of microplastics in different urban runoff

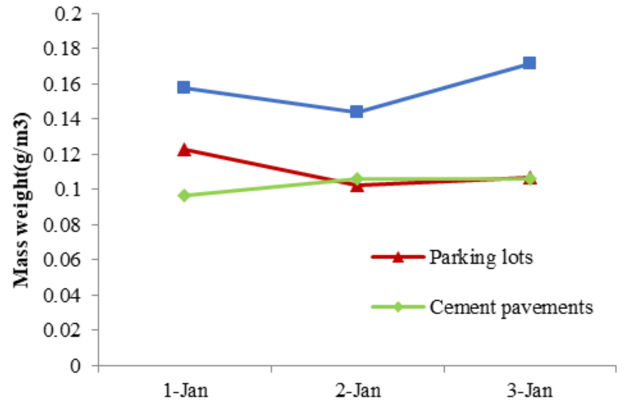

Fig. 1. The average mass weight of microplastics in different urban runoff

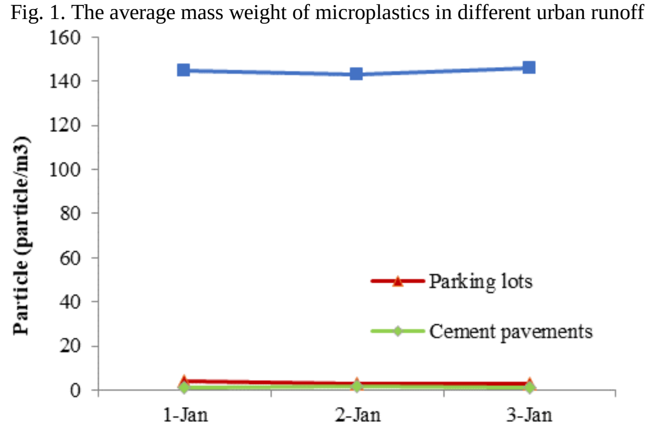

Fig. 2. The average concentrations of microplastics in different urban runoff

Figure 1 & 2 showed that microplastics pollution occur in residential areas, parking lots and urban cement pavements with the average concentrations of microplastics, 145 particle/m^3, 3 particle/m^3 and 1 particle/m^3, respectively. And the average mass concentration of microplastics are almost 0.1~0.15 g/m^3 in all three kinds of surface runoff. Both two figures indicated the occurrence of microplastics in urban runoff, the concentrations in different surfaces may vary from one to another, while the mass weight may be close to each other. It may be highly due to non-standardized detection methods to quantify microplastics currently (Mai et al., 2018). In comparison with the above results (Fig. 1 & 2), it indirectly presented that counting by visual sorting may be a better method to analyze the concentrations of microplastics instead of mass weight by analytic balance.

B. Characteristics of microplastics distribution

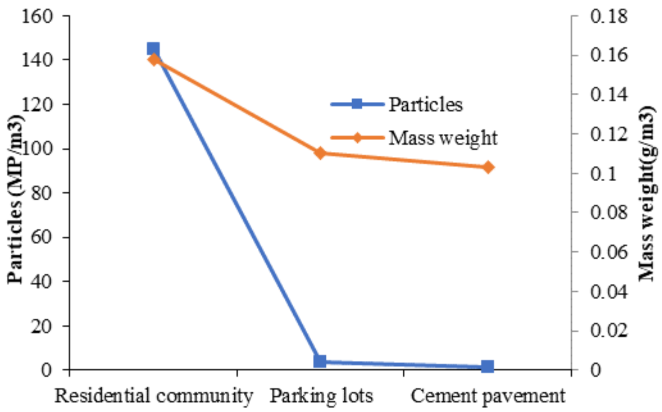

Fig. 3. Characteristics of microplastics distribution in urban runoff

The occurrence of microplastics in urban runoff during rainfall events was evident (Figure 1 & 2). The characteristics and difference between different urban surface runoff could be best illustrated with the further results in this study, as presented in Figure 3. The order of concentrations of microplastics in urban runoff is Residential roads > Parking lots ≈ Cement pavement.

This study mainly focused on the concentrations and mass of microplastics in different urban runoff, indicating that microplastics pollution in urban runoff is a source of marine microplastic pollution. There is no specific analysis of microplastic materials such as PP, PE and other components, which need to be further investigated and discussed.

The results showed that the cumulative intensities of parking lots and urban cement pavements are much lower than residential roads, which might be highly due to frequently used plastics around these areas, such as courier bags, breakfast bags, and plastic bottles, which could be decomposed and fragmented into microplastics over time. The microplastics pollution are less but still found in the road pavement because the automobile tires contain some microplastics, and the quantity is few from automobiles.

C. Potential harms to surface water body

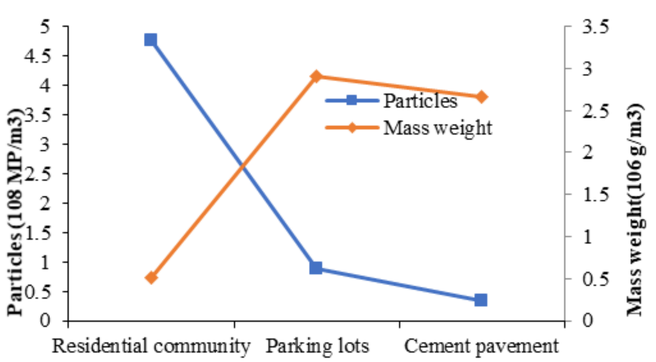

Fig. 4. Potential contributions of microplastics pollution from urban runoff to surface water body

According to annual rainfall intensity of ~600 mm in Luoyang, China, this study assessed the potential contributions of microplastics pollution from different urban runoff to surface water body. From the figure 4, the results showed that the order of contributions of microplastics concentrations in urban runoff is Residential roads > Parking lots ≈ Cement pavement, but the mass weight is converse. The results showed that the microplastics may have a distinct difference among different urban runoff so that their contributions to surface water body are significantly different, which need to be further investigated in the future study.

IV. Conclusions

Microplastics pollution occur in residential areas, parking lots and urban cement pavements with the average concentrations of microplastics, 145 particle/m^3, 3 particle/m^3 and 1 particle/m^3, respectively. The cumulative intensities of parking lots and urban cement pavements are much lower than residential roads, which might be highly due to frequently used plastics around these areas. Meanwhile, according to the calculation in this study, microplastics pollution in urban surface runoff may play a significant role in the contribution to that pollution in subsequent rivers and coastal oceans. To the best of our knowledge, this study is the first one to analyze the microplastics pollution in different urban runoff and relate the contribution analysis of urban runoof among different characteriss to the microplastics pollution in marine or freshwater systems.

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