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Assessing the Mass Concentration of Microplastics and Nanoplastics in Wastewater Treatment Plants by Pyrolysis Gas Chromatography−Mass Spectrometry

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Abstract : The level and removal of microplastics (MPs) in wastewater treatment plants (WWTPs) has been well evaluated by the particle number, while the mass concentration of MPs and especially nanoplastics (NPs) remains unclear. In this study, microfiltration, ultrafiltration and hydrogen peroxide digestion were used to extract MPs and NPs with different size ranges (0.01−1, 1−50, and 50−1000 μm) across the whole treatment schemes in two WWTPs. By identifying specific pyrolysis products, pyrolysis gas chromatography−mass spectrometry were used to quantify their mass concentrations of selected six types of polymers (i.e., polymethyl methacrylate (PMMA), polypropylene (PP), polystyrene (PS), polyethylene (PE), polyethylene terephthalate (PET), and polyamide (PA)). The mass concentrations of total MPs and NPs decreased from 26.23 and 11.28 μg/L in the influent to 1.75 and 0.71 μg/L in the effluent, with removal rates of 93.3 and 93.7% in plants A and B, respectively. Among them, PP, PET and PE were the dominant polymer types in wastewater, while PMMA, PS and PA only accounted for a small part. The mass concentrations of NPs (0.01−1 μm) were much lower than those of MPs (>1 μm), accounting for 12.0−17.9 and 5.6− 19.5% of the total MPs and NPs, respectively. Notably, the removal efficiency differed with the polymer type and size range. The low-density MPs (e.g., PP and PE) had lower removal efficiency than high-density PET in both plants. Since particles with smaller size could pass the tertiary sand filter or membrane filter more easily, the removal efficiency of NPs was lower than that of MPs with larger particle size. Based on annual wastewater effluent discharge, it is estimated that about 0.321 and 0.052 tons of MPs and NPs were released into the river each year. Overall, this study investigated the mass concentration of MPs and NPs with a wide size range of 0.01−1000 μm in wastewater, which provided valuable information regarding the pollution level and distribution characteristics of MPs, especially NPs, in WWTPs. However, there are limitations and uncertainties in the current study, especially regarding the sample collection and MP/NP detection. The used plastic items (e.g., sampling buckets, ultrafiltration membranes, centrifugal tubes, and pipette tips) may introduce potential contamination. Additionally, the proposed method caused loss of MPs, especially NPs, which can lead to underestimation of MPs/NPs. Further studies are recommended to address these challenges about MPs/NPs in wastewater.

Keywords : microplastics, nanoplastics, mass concentration, WWTPs, Py-GC/MS
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