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Microplastic accumulation in sewer sediments and their pathways to the environment via combined sewer overflows

Accumulation de microplastiques dans les dépôts de réseaux d'eaux usées unitaires et leur transfert vers l'environnement via les déversoirs d'orage

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RÉSUMÉ

Les contaminants particuliers présents dans les eaux usées peuvent se déposer et former des dépôts dans les réseaux d'assainissement pendant leur transport vers les stations d'épuration. Dans les réseaux unitaires, pendant les périodes de pluie, les dépôts peuvent être remobilisés et transférer vers les eaux usées les contaminants piégés. Ces contaminants peuvent se déverser dans l'environnement via les déversoirs d'orage (DO) lors d'événements intenses. Les microplastiques (MP) qui sont abondamment présents dans les eaux usées peuvent se comporter de la même manière que les contaminants particuliers - piégés dans les dépôts d'égouts et libérés ensuite dans les eaux usées. L'accumulation des MP dans les sédiments des réseaux et leur contribution au flux de microplastiques rejeté dans l'environnement via les DO sont toutefois inconnues. Cette étude vise à fournir une idée de la contamination en MP des dépôts en réseau unitaire et des DO, et contribue à augmenter les connaissances sur l'occurrence et le devenir des MP dans le continuum réseau d'assainissement - STEP avant de rejoindre l'hydrosystème naturel.

ABSTRACT

Particulate contaminants in wastewater can settle down and form in-sewer deposits during transport to wastewater treatment plants. In combined sewer, during wet weather periods, sewer deposits can be remobilized and release the trapped contaminants into wastewater. These contaminants can get discharged along with combined sewer overflows (CSOs) into the environment during intense events. Microplastics (MPs) that are abundantly present in wastewater may behave similarly to particulate contaminants – trapped in sewer deposits and released later into wastewater. The accumulation of MPs in sewer sediments and its contribution to the amount of plastics entering the environment along with CSOs are however unknown. Therefore, this study aims to provide an idea about MPs contamination of sewer deposits and CSOs, thereby increase the knowledge on MPs occurrence and fate in the sewer network – WWTP continuum and their pathways in urban waters before entering the environment.

KEYWORDS

combined sewer overflows, microplastics, sewer deposits, sewer sediments, wastewater

1 INTRODUCTION

Sewage management systems play an important role in sanitation and disease prevention for humans, as well as environmental practices. As a main component of a sewer system, sewer network is responsible for conveying wastewater from household, commercial or industrial establishments to WWTPs. In case of combined sewer systems, mixture of wastewater and urban runoff is transported to WWTPs for purification. During the transport, particulate contaminants in wastewater can settle down inside the sewer network, leading to the formation of sewer deposits or sewer sediments. Sedimentation happens due to moderate flow rate of sewage during low activity periods (mainly nights) and dry weather periods. This phenomenon is pronounced in the case of the Parisian combined sewer systems where sewer pipes are oversized with some low-slope sections. During wet weather periods, an increase in flow rate can resuspend sediments inside the sewer network. This releases contaminants trapped in sewer sediments into wastewater. Gasperi et al. (2010) indicated in-sewer deposit erosion acts as the major source of total suspended solids and organic pollution in wet weather flows. Particularly, in case of intense events, total water volume in the networks may exceed the capacity of WWTPs and be discharged directly to the environment. These discharges, named combined sewer overflows (CSOs), can add a considerable amount of contaminants into receiving water bodies without treatment.

As demonstrated in the literature, MPs are abundantly present in wastewater, reflecting the wide application of plastic and plastic-contained products in human modern daily life. They are expected to behave similarly to other contaminants in sewage – trapped in sewer sediments and released into wastewater later. The accumulation of MPs in sewer sediments and its contribution to the amount of plastics entering the environment along with CSOs are however unknown. Therefore, this study aims to provide an idea about MPs content inside sewer sediments and CSOs, thereby increase the knowledge on MPs occurrence and fate in the sewer network – WWTP continuum and their pathways in urban waters before entering the environment.

2 MATERIALS AND METHODS

2.1 Sample collection and pretreatment for sewer sediments

A total of twelve samples were taken from different sand chambers located inside Paris combined sewer networks from March to August 2021. These samples were stored in glass jars at 5°C before analysis.

The collected sewer sediments were highly heterogeneous from organic-rich to grainy components. They were freeze-dried to remove water content and sieved through 5mm mesh to discard large items. A subsample of 0.5g then underwent chemical oxidation with H_2O_2 and density separation with NaI to isolate MPs from the environmental matrix. Treated samples were later deposited on Anodisc filters for further chemical identification.

Besides, particulate organic carbon was measured for all sewer sediment samples.

2.2 Sample collection and pretreatment for CSOs

Twenty-five samples from two major CSO outfalls in Paris region (i.e., Clichy and La Briche) were collected during intense events from April to October 2022. Samples were first fractionated with a 500µm metallic mesh. Fraction larger than 500µm retained on the mesh was stored in a Petri dish, while smaller fraction was concentrated on 10µm mesh before going through an enzymatic treatment with SDS, protease and cellulase for MPs extraction. Extracted samples were then deposited on Anodisc filters for chemical analysis.

2.3 Chemical analysis and data processing for both sample types

Samples were analyzed by scanning Anodisc filters with the automated µ-FTIR mapping (Nicolet iN10 MX, Thermo Scientific, 25×25µm pixel resolution). Data processing was carried out later with the siMPle software to identify the polymer composition of the particles.

3 RESULTS AND DISCUSSIONS

MPs were found in all sewer deposit samples with most of detected particles smaller than 500µm. The

number concentration varied from 5×10^3 to 178×10^3 particle/kg dry weight. Despite a small number of samples, there was no relation between MP contamination and particulate organic carbon content of the samples observed. Polyester (PE), polypropylene (PP), polystyrene (PS) and cellulose acetate are most common polymers found in this sample type.

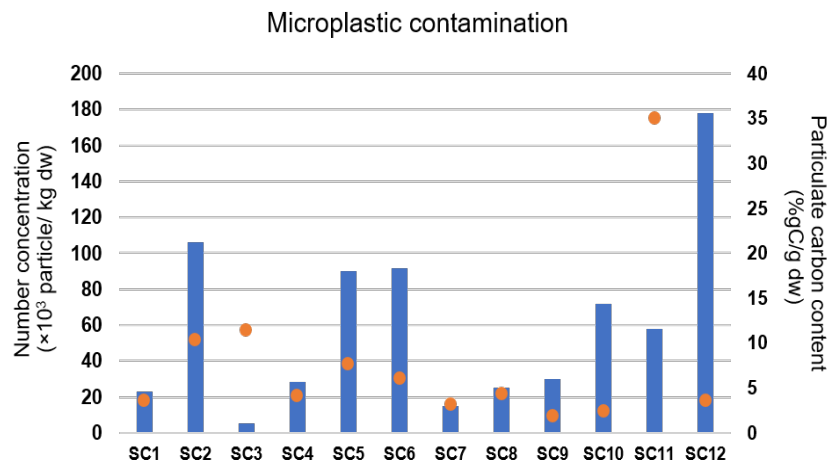


Figure 1: Correlation between microplastic contamination (left axis) and particulate carbon content (right axis) in sewer sediments

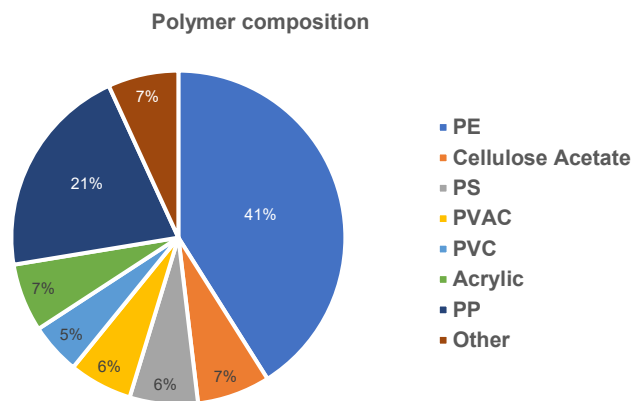


Figure 2: Polymer composition of detected particles in sewer sediments

CSO samples are in the processing steps for sample preparation. They will be analyzed for final results in upcoming weeks.

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