Abstract

Plastics have become an integral part of modern human life. With a high-density population, metropolitan areas have become hotspots of plastic consumption and disposal. The abundance of microplastics (MPs) in urban wastewater reflects the plastic pollution issue in these areas. Since the contamination of humans and ecosystems with MPs are of great concern, understanding the inputs of MPs into the environment is crucial to support the implementation of mitigation measures. In this context, this PhD project focused on studying the occurrence and fate of MPs in the Parisian wastewater management system, aiming to investigate and evaluate various pathways through which MPs are released from urban areas into the surrounding environment.

Over the last decade, plastic research has primarily focused on the role of municipal wastewater treatment plants (WWTPs) in addressing MP-polluted wastewater. Existing water treatment technologies at these facilities have demonstrated high efficiencies in separating MPs from wastewater; however, WWTP effluents remain a significant input of MPs into the environment due to their large discharge volume. In addition, literature has highlighted the transfer of MPs into sewage sludge. This byproduct of water treatment serves as a potential source of MPs once disposed of into the environment. By investigating MPs in sludge at various treatment steps, this study found that current sludge treatment technologies were inefficient in completely removing MPs. There was no significant reduction in MP abundance observed after all treatment processes. Contamination levels remaining in the final treated sludge ranged from 8.6×10^4 to 4.5×10^5 particle/kg dry weight (dw) of MPs >25 µm, analyzed by µ-FTIR. Approximately 7 % of sludge-based MPs were returned back to the system via reject water from dewatering processes. Additionally, thermal treatment at high temperatures induced the fragmentation of plastic particles, leading to a reduction in their size. The findings in this study emphasize the potential incorporation and accumulation of MPs in agricultural soils via sludge application, resulting in soil contamination.

While MPs in WWTPs have been extensively studied over the last decade, little attention has been paid at their fate and occurrence during transport within the sewer network before reaching

treatment facilities. To address this knowledge gap, this study investigated the potential accumulation of MPs in sewer sediments, which serve as a stock of pollutants inside the sewer system. High concentrations of MPs, ranging from 5×10^3 to 178×10^3 particle/kg dw, were found in these sediments. This indicates the temporal storage of MPs in sewer sediments instead of arriving at WWTPs. This finding highlights the significant stock of MPs inside the sewer network and the associated risk of downstream transfer during wet weather events due to the resuspension of in-sewer sediments.

Combined sewer overflows (CSOs), one of the main untreated discharges from the combined sewage system, are expected to transfer a large number of MPs into receiving waters. However, research on this pathway is still limited. Therefore, a study to evaluate the quality of CSOs in terms of MP contamination and their potential to emit MPs into the environment was carried out. High MP levels were detected in CSOs during different storm events, ranging from 6.7×10^4 to 3.9×10^5 particle/m^3. At an annual scale, the number of MPs released with CSOs was equivalent to the massive load from treated wastewater, despite much lower discharge volumes. Thus, these findings confirm the significant role of CSOs as a land-based source of MPs into the surrounding environment during intense wet weather events.

In conclusion, this PhD project has provided data on MP contamination levels in various compartments of the wastewater management system, including the sewer network and the sludge-line treatment at WWTPs. It has also elucidated the contribution of various pathways for releasing MPs from urban areas into the environment, thereby underscoring the inadequacy of existing wastewater management systems in addressing plastic pollution.