Sources to Microplastics in Urban Stormwater Catchments: an FTIR-GIS approach for identification and mapping

Sources de microplastiques dans les bassins versants urbains : une approche FTIR-GIS pour l'identification et la cartographie

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RÉSUMÉ

Les microplastiques (MP) sont de plus en plus reconnus comme des polluants majeurs dans les systèmes urbains de gestion des eaux pluviales. Il est essentiel d'identifier leurs sources dans les bassins versants urbains complexes afin de mettre en place des mesures d'atténuation efficaces. Cette étude propose une approche intégrée utilisant la spectroscopie infrarouge à transformée de Fourier (FTIR) portable et les systèmes d'information géographique (SIG) pour permettre l'identification rapide des polymères sur le terrain et la cartographie spatiale des sources de pollution. Les travaux sur le terrain seront menés au printemps 2026 et cibleront les routes, les parkings et les toits. La méthodologie combinée FTIR-SIG vise à soutenir les stratégies de contrôle à la source et à améliorer la compréhension de la dynamique de la pollution plastique dans les environnements urbains.

ABSTRACT

Microplastics (MPs) are increasingly recognized as major pollutants in urban stormwater systems. Identifying sources within complex urban catchments is essential for effective mitigation. This study proposes an integrated approach using handheld Fourier Transform Infrared (FTIR) spectroscopy and Geographic Information Systems (GIS) to enable rapid, in-field polymer identification and spatial mapping of pollutant sources. Fieldwork will be conducted in spring 2026, for example urban catchments, including buildings, street furniture and litter, and traffic. The combined FTIR-GIS methodology aims to support source control strategies and improve understanding of plastic pollution origin in urban environments.

KEYWORDS

Plastics, Source Identification, FTIR, Source Control, Urban Catchments

1 BACKGROUND

Microplastics (MPs), defined as plastic particles smaller than 5 mm, and tyre wear particles (TWPs) have become widespread pollutants in aquatic environment (Ashrafy *et al.*, 2023). Urban stormwater runoff serves as a major transport pathway, carrying MPs and TWPs from roads, rooftops, and other impervious surfaces into receiving water bodies (Samson, 2024). Recent research highlights the complexity of microplastic pollution in urban runoff. Lindfors et al., 2025 found that MPs and tyre wear particles occur across various urban surfaces, including roads, parking lots, and rooftops, with TWPs contributing over 60% of the combined particle mass. Notably, TWPs were detected in roof runoff, indicating the role of atmospheric deposition and resuspension. The complexity of urban catchments makes it challenging to identify which MP pollutants are present and where they originate.

Fourier Transform Infrared (FTIR) spectroscopy is widely used to determine the polymer composition of MPs. This technique detects the unique vibrational modes of molecular bonds, producing characteristic spectra that can be matched to reference libraries. Laboratory-based FTIR systems (e.g., micro-FTIR or FTIR imaging) provide high-resolution analysis but are time-consuming and require extensive sample preparation (AZO Materials, 2025). Moreover, samples must be removed from the catchment, which can involve surface disruption.

In contrast, handheld FTIR spectrometers offer a portable, rapid, and non-destructive alternative for in-field identification of plastics. These devices enable real-time polymer identification at the point of collection, supporting spatial mapping of MP types across a catchment. This capability is particularly valuable for source tracking, allowing researchers to link specific polymers to potential sources such as road surfaces (e.g., styrene-butadiene rubber from tires), construction materials (e.g., PVC), or consumer waste (e.g., polyethylene from packaging) (Agilent, 2023).

Recent advancements in handheld FTIR technology have improved spectral resolution and expanded onboard polymer libraries, making these instruments increasingly suitable for environmental monitoring. For example, Agilent's 4300 Handheld FTIR and Thermo Fisher's TruDefender FTX are designed for field use, offering robust performance under diverse environmental conditions. Such devices have even been applied in studies assessing food quality (Cebi *et al.*, 2023). However, limitations remain: handheld FTIR instruments are less effective for particles smaller than 500 µm and may struggle with complex or weathered polymers. Additionally, surface contamination and environmental matrices can interfere with spectral clarity, requiring careful sample handling and occasional pre-cleaning (Mhaddolkar et al., 2024).

Despite these challenges, integrating handheld FTIR into stormwater monitoring protocols represents a promising step toward more agile and spatially resolved microplastic source identification. This approach supports targeted mitigation strategies and enhances our understanding of plastic pollution dynamics within urban catchments.

The aim of this study is to identify and spatially map sources of microplastics and tyre wear particles within an urban stormwater catchment using a combined handheld FTIR spectroscopy and GIS approach.

2 METHODS

A handheld Fourier Transform Infrared (FTIR) spectrometer (Figure 1), produced by Agilent (Agilent, 2024) will be employed to identify plastic types within the urban catchment area. Sampling locations will be selected based on land-use characteristics, proximity to drainage infrastructure, and potential pollutant sources. At each site, surface materials will be scanned using the FTIR device, which provides spectral fingerprints for material classification. These spectra will be compared against a reference library to determine polymer types.

Figure 1 *Left: Handheld FTIR Spectrometer; Right: Measurement process.*

Geospatial data will be collected concurrently using a GPS-enabled tablet to record the coordinates of each sampling point. Identified materials will be categorized and linked to their spatial locations within a Geographic Information System (GIS) environment. The GIS database will integrate land-use maps, stormwater network layers, and material distribution data to visualize pollutant source patterns. Spatial analysis techniques, including hotspot mapping and overlay analysis, will be applied to identify areas with high concentrations of pollutant-generating materials.

3 CONCLUSIONS AND FUTURE WORK

Future work will focus on validating the FTIR-GIS approach by comparing results from this study with data from previous sampling campaigns within the same catchment. This comparison will assess the accuracy of pollutant source identification and spatial mapping, providing insights into the reliability of handheld FTIR devices for urban material characterization. Additionally, the integration of FTIR data with geospatial tools will be evaluated for its effectiveness in source tracking. These findings will inform methodological refinements and support the development of standardized protocols for identifying and mapping pollutant sources in urban environments, ultimately contributing to improved stormwater management and pollution prevention strategies.

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