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Spatial and temporal distribution of organic matter and molecules in the sediments of the City of Paris sewerage system. Link with practices and uses during the Anthropocene using a multi-proxy approach.

C. Asselin^{1*}, J. Jacob¹, T. Thiebault², G. Bernier-Turpin³ & R. Moilleron³

¹ *Laboratoire des Sciences du Climat et de l'Environnement (LSCE-IPSL), UMR 8212 (CEA/CNRS/UVSQ), Université Paris-Saclay, Orme des merisiers, 91190 Saint Aubin, France*

² *EPHE, PSL University, UMR 7619 METIS (SU/CNRS/EPHE), Jussieu, 75005 Paris, France*

³ *LEESU, Ecole des Ponts, Université Paris Est Créteil, 61 avenue du Général de Gaulle, 94010 Créteil Cedex, France*

*Corresponding author email: camille.asselin@lsce.ipsl.fr

Highlights

- Delineation of the sewershed of silt trap to be able to precisely trace the sources of particles.
- Comparison of pharmaceutical products recorded in sediment and consumer populations.
- Spatial and temporal distribution of pharmaceuticals in Paris sewer sediments.

Introduction

For 5 000 years, cities have been the universal centres of society, concentrating the functions of authority, exchange and the production of wealth. Despite these foundations, all cities are different in terms of demography, size, morphology, cultural diversity and landscape (Humain-Lamoure and Laporte, 2022). These differences give rise to numerous heterogeneities between cities, but also within cities (Bellidenty and Martinez, 2015; Madoré, 2015, 2005; Sabatini, 2006). The exponential growth of urbanisation since the beginning of the 20th century will lead to more than two thirds of the population living in urban centres by 2050, at the expense of rural areas (Carneiro Freire et al., 2019). This rapid urbanisation leads to problems of poverty, urban congestion, pollution, access to services, mental stress and adaptation to climate change, all of which manifest themselves in different ways within a single city. This growing urbanisation and the heterogeneity within cities pose major challenges that require effective urban planning for sustainable urban management.

Silt

How can we account for these heterogeneities in the urban environment and their changes? The sediments that transit in the sewerage system store relevant information on the recent evolution of urban socio-ecosystems through the molecules they carry (Jacob et al., 2020). In Paris, previous studies have focused on the identification/location of pollution sources or the determination of their spatio-temporal distribution, on different types of pollution: plastic (Treilles et al., 2021a, 2021b) and chemical (PAHs (Gasperi et al., 2005; Rocher et al., 2004b), metals (Moilleron et al., 2005; Rocher et al., 2004a), biocides (Paijens et al., 2020), etc.).

The study of pollution in wastewater systems can be diverted from its initial objectives to define the state and study the trajectory of urban systems (Choi et al., 2020, 2019, 2018). This involves a paradigm shift by considering materials in transit or deposited not as pollutants, but as tracers, indicators and metrics that can be used to support public policy.

The ANR EGOUT project (Geochemical Observations of Urban Trajectories; egout.cnrs.fr) aims to identify the socio-economic and environmental factors that control the spatial and temporal distribution of materials in the Parisian sewer system, in order to propose innovative tools for managing the urban environment.

Methodology

Delimitation and selection of sewersheds

The Paris sewerage network is criss-crossed by 159 silt trap (ST), which collect sediment to prevent the network from becoming saturated. Each ST is cleaned every 1 to 3 years and collects the sediment that passes through the combined sewer system (domestic sewage and rainwater). In order to relate the results of the geochemical analysis of the sediments to the corresponding sewershed (individual connection to individual addresses and cadastral parcels), it was first necessary to define the sewershed of each ST on the basis of the drainage networks, taking into account two drainage scales (wet weather and dry weather) and highlighting a sediment cascade system (Asselin et al., submitted).

Of the 159 ST, 6 were selected on the basis of a clear definition of the sewershed, the possibility to compare geochemical data (at the sewershed scale) with socio-economic data (at the IRIS grid scale) and socio-economic diversity (INSEE data; (Asselin et al., in prep).

Samples and analyses

In June 2023, 24 sediment cores were collected from these 6 ST. The sediments are stratified with two different facies: a light, coarse, mineral facies and a dark, fine, organic facies. The cores were sampled according to these different facies. Total organic matter parameters (COT, IH, IO, Tmax, C/N, $\delta^{13}\text{C}$ et $\delta^{15}\text{N}$) were determined using Rock-Eval pyrolysis and an elemental analyser coupled to an isotope ratio mass spectrometer. At the same time, around sixty organic molecules (pharmaceuticals, legal and illegal drugs and food tracers) were identified and quantified in the sediments after extraction and analysed with high performance liquid chromatography coupled to two tandem mass spectrometers.

Case study

The 6 core samples are located in contrasting areas of Paris (Figure 1). Two ST (Boissy d'Anglas and Guynemer) are in well-to-do areas, two ST (Islettes and Voltaire) are in neighbourhoods with socially mixed populations and the last two (Pantin and Domrémy) are in vulnerable areas.

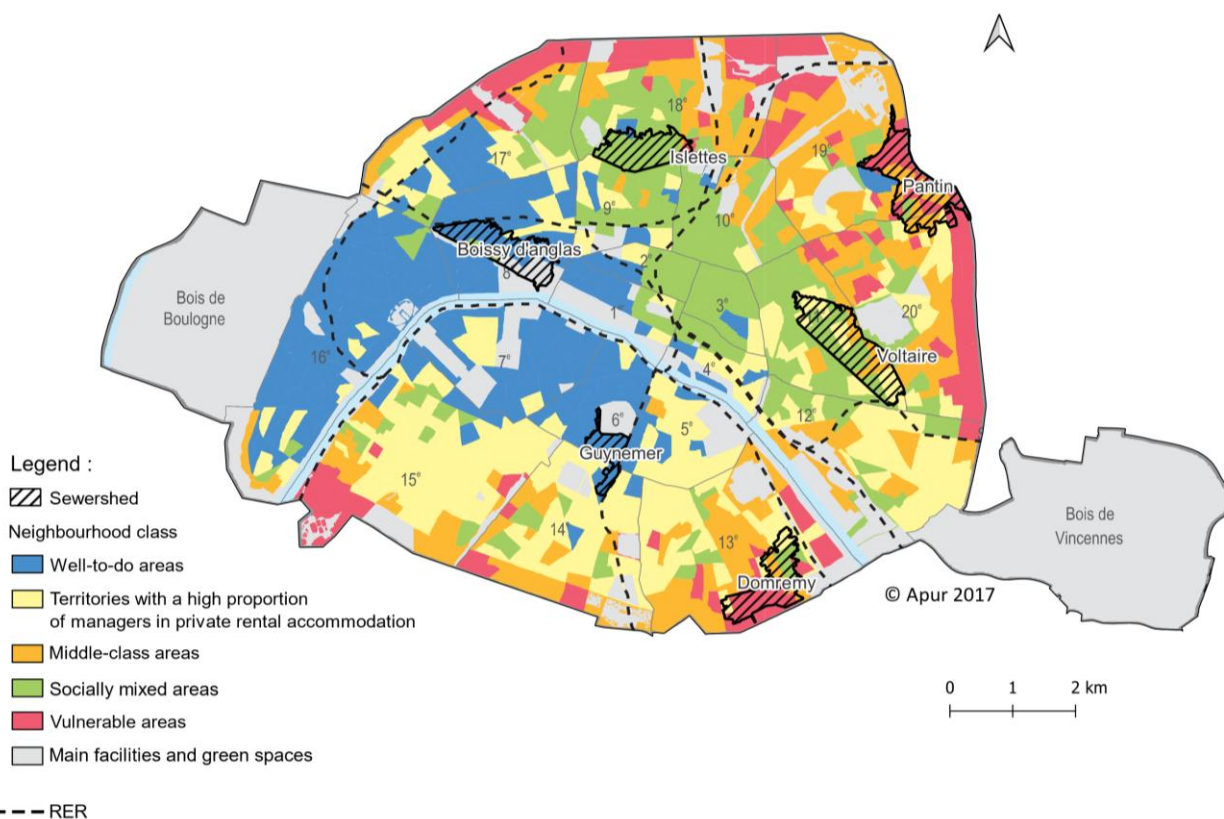


Figure 1. Sewershed of the 6 ST selected according to the socio-economic classes of the neighbourhoods.

The socio-economic diversity between the different study sites is important in order to compare geochemical results with socio-economic parameters, while maintaining a representation of intra-urban heterogeneity.

Results and discussion

These results make it possible to discuss the spatial distribution (differences between cores) and temporal distribution (vertical evolution) of matter and organic molecules in relation to the socio-economic specificities of each input zone. Our results also provide essential information on how these molecules are archived in the sediments, depending on the facies and speciation of these molecules.

It seems possible to formulate two working hypotheses, the first being that we can expect to observe a heterogeneous spatial distribution of licit and illicit drug consumption, and the second indicating that antihistamine consumption evolves over time according to the seasons.

Conclusions and future work

As the analyses are still in their early stages, it is impossible to draw any conclusions at the moment, but by June 2024 the work will have progressed.

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