



# Assessment of 34 dissolved and particulate organic and metallic micropollutants discharged at the outlet of two contrasted urban catchments

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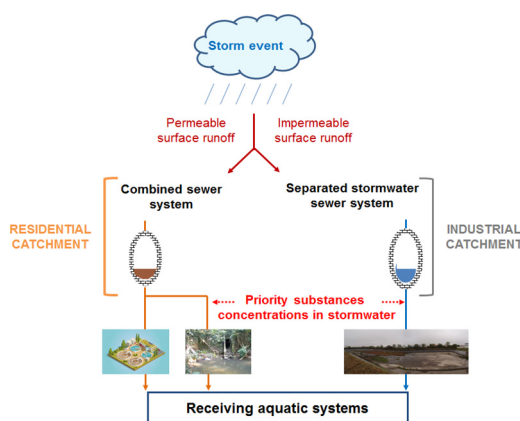
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## HIGHLIGHTS

- Among 34 micropollutants analysed in both dissolved and particulate fractions, 24 were detected in both catchments.
- Distribution between the particulate and the dissolved phases provides information for urban stormwater practitioners.
- PS loads discharged into receiving water bodies were higher for stormwater runoff in separate sewer system than in CSOs.
- Comparison between the PS loads discharged by CSOs by a wastewater treatment plant at the daily time scale.

## GRAPHICAL ABSTRACT



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## ABSTRACT

The assessment of micropollutants in urban wet weather discharges is essential to improve the knowledge of the impact of such discharges on receiving waters. This study assessed the quality of combined sewer overflows (CSOs) in Ecully (residential catchment) and stormwater runoff in Chassieu (industrial catchment) during rain events by providing data on occurrence and total event mean concentrations (EMC<sub>t</sub>) of 34 priority substances (PS) (9 metals, 13 pesticides, 6 PAHs, 4 alkylphenols and 2 chlorobenzenes) in dissolved and particulate fractions. Over 34 substances monitored, 23 were quantified in urban wet weather discharges of both catchments. For both catchments, 9 metals and 6 PAHs monitored were always quantified, reflecting their ubiquitous presence. For other organic pollutants, only 5 pesticides were quantified and only 2 alkylphenols were measured solely in dissolved fraction. A significant site-to-site difference was observed for metals, PAHs and alkylphenols. The highest concentrations were measured in stormwater runoff in Chassieu vs. Ecully. On the contrary, the diuron concentrations were highest in CSO discharges in Ecully. Distribution of the PS between particulate and dissolved fractions provides information for urban stormwater practitioners. Most PS in urban wet weather discharges were mainly linked to particles (PAHs, Pb, Ti for example). The comparison between daily flows of wastewater treatment plants during dry weather and CSOs daily flows in Ecully showed that stormwater was the most

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important source of contamination for fluoranthene, benzo(b)fluoranthene and benzo(k)fluoranthene and 7 metals (As, Cr, Co, Cu, Pb, Ti and Zn) in receiving water bodies, but not for pesticides and alkylphenols.

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## 1. Introduction

The expansion of urbanisation generates increasing pollutant loads discharged into the aquatic environment from urban drainage systems during rain events. Indeed, land use modifications associated with urbanisation result in additional stormwater release and increased flooding. Furthermore, urbanisation exerts a strong influence on the quality of stormwater, which is being increasingly contaminated by a variety of biological and/or physical pollutants stemming from anthropogenic activities commonly practiced in urban areas (Fletcher et al., 2013; Yao et al., 2016).

The European Water Framework Directive (WFD) came into force in 2000 to ensure a good ecological and chemical status of surface and ground water bodies (European Commission, 2000). A list of 33 priority substances (PS), which represent a significant risk for the aquatic environment, was established. The European Directive 2008/105/EC set environmental quality standards (EQS) for these 33 substances (European Commission, 2008).

To reduce pollutants emissions into receiving water bodies, it is necessary to have a better knowledge of micropollutant sources. In urban catchments, urban wet weather discharges (UWWDs) into aquatic environments come from i) wastewater treatment plant (WWTP) outlets (mixture of treated sewage water and stormwater), ii) overflow facilities (mixture of untreated sewage and stormwater) and iii) stormwater outlets (generally untreated stormwater) (Chocat, 1997). UWWDs cause significant impacts on receiving water bodies and on aquatic life. The effects are obviously most severe for receiving waters draining heavily urbanized watersheds (Hoffman et al., 2002). However, some studies have also shown important aquatic life impacts for streams in watersheds that are <10% urbanized (Pitt, 2002). A number of studies have been undertaken to identify priority substances in wastewaters (Rule et al., 2006; Eriksson et al., 2010), in wastewater treatment plants influent, effluent and sludge (Martin Ruel et al., 2012; Gros et al., 2017) and in receiving waters (Luo et al., 2014; Stamm et al., 2016). However, data on micropollutant contamination of UWWDs in both separate and combined sewers are still limited (Björklund et al., 2009; Birch et al., 2011; Zgheib et al., 2012; Launay et al., 2016). Previous studies focused mainly on main water pollution constituents (nutrients, chemical oxygen demand (COD), total suspended solids (TSS)), and also on selected micropollutants such as heavy metals and polycyclic aromatic hydrocarbons (PAHs) (Burton and Pitt, 2002; Brown and Peake, 2006).

Knowledge on dissolved/particulate partitioning of micropollutants is important to i) plan out stormwater discharges treatment e.g. by retention or infiltration basins, or swales and ii) better assess pollutant transfer and impact on receiving aquatic systems. To date, only few studies report such data for PS in UWWDs. And studies dealing with PS partitioning are limited. (e.g. Björklund et al., 2009; Zgheib et al., 2012; Kalmykova et al., 2013).

To provide new data on PS concentrations and partitioning in UWWDs, the outlet of two urban catchments in Lyon, France were equipped for sampling stormwater before its discharge into 1) a peri-urban river in a residential area (Ecully catchment) and 2) a detention basin at the outlet of an industrial area (Chassieu catchment). The aim of this study was to characterize combined sewer overflows (CSOs) in Ecully and stormwater in Chassieu for 34 micropollutants, including 28 priority substances listed in the WFD (pesticides, PAHs, metals and alkylphenols). The specific objectives were to i) determine total event mean concentrations (EMCt) for these two contrasted sites during

two years (2008–2009) and their occurrence; ii) to investigate PS partitioning between dissolved and particulate fractions and, finally, iii) compare the PS loads discharged by CSOs to the PS loads discharged by a WWTP at the daily time scale. These data were also used to evaluate on the respective contributions of rainwater, dry atmospheric deposition, dry weather discharge and runoff on catchment to 13 pollutant loads in urban wet weather discharges at the outlet of the two catchments in Becouze-Lareure et al. (2015).

## 2. Materials and methods

### 2.1. Site description and sampling procedure

Monitoring campaigns were carried out at the outlet of two experimental catchments: Ecully and Chassieu, located in the Greater Lyon area. The Ecully residential catchment is drained by a combined sewer system (CS). The Chassieu catchment is an industrial area drained by a separate stormwater sewer system (SS); the stormwater runoff is discharged into a detention and settling basin and then into an infiltration basin which recharges the groundwater table. The main characteristics of both sites are presented in Table 1.

Both sites were equipped and monitored as part of the Field Observatory on Urban Hydrology (OTHU) ([www.othu.org](http://www.othu.org)). At the catchment outlets, a set of sensors allows continuous monitoring (with a 2 min time step) of water depth, flow velocity and quality parameters (pH, conductivity, turbidity, temperature).

At each site, UWWDs were sampled using refrigerated automatic samplers with Teflon® pipes volumetric vacuum pump and a set of twenty-four 1 L glass bottles. For each event, a flow-weighted event mean sample was obtained according to the procedure described in detail in Becouze-Lareure et al. (2015). The analysis occurred 48 h maximum after the sampling. The results presented in this paper have been analysed in 2008 and 2009.

In total, 34 pollutants have been measured, owing to 5 families:

- 9 metals (Ms): arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), nickel (Ni), lead (Pb), titanium (Ti), zinc (Zn).
- 13 pesticides (Pest): alachlore,  $\gamma$ -hexachlorocyclohexane, trifluraline, aldrine, endrine, isodrine, op DDT, pp. DDT, atrazine, chlorfenvinphos, diuron, isoproturon, simazine.

**Table 1**  
Main characteristics of the two experimental catchments (Lyon, France).

	Chassieu	Ecully
Location	East of Lyon	West of Lyon
Geographical reference	45°44'10.30"N/4°57'31.27"E	45°45'57.88"N/4°46'09.77"E
Sewer type	Separate	Combined
Area (ha)	185	245
Land use (% of area)	Industrial	Residential
Impervious surface	72	34
Urban green space	20	60
Agricultural use	4	5
Natural use	4	1
Active surface (ha)	54	60
Land slope (%)	0.4	2
Population density (inhab/ha)	–	28.6
Traffic (vehicles/day)	10,000	No data
Number of companies	1267	–

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