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Priority pollutants in urban stormwater: Part 1 – Case of separate storm sewers

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ABSTRACT

Organic and mineral pollutants have become part of today's urban environment. During a rain event, stormwater quality as well as the corresponding contaminant loads is affected by both atmospheric deposition and the various types of impervious surfaces (roads, rooftops, parking lots etc.) on which runoff occurs. This study provides results on stormwater pollution in Paris and its suburbs from three separate storm sewers ($n = 20$ samples). These results show that the stormwater had been contaminated by 55 chemical substances out of the 88 investigated. A particular attention was given to stormwater particle contamination. Concentrations are provided for: metals, PAHs, PCBs, organotins, alkylphenols, phthalates, pesticides, and VOCs. Our findings are among the first available in the literature since the relevant analyses were all conducted on both the particulate (P) and dissolved (D) phases. For most substances, particles from the three storm sewers were more heavily contaminated than dredged sediments and settleable particles from the Seine River. As a consequence of this finding, the release of untreated stormwater discharges may impact the receiving waters and contribute to sediment contamination.

1. Introduction

Urban expansion across Europe has significantly affected all types of ecosystems, in leading to increased pollution, habitat fragmentation, biodiversity loss, and adverse effects on natural resources. More specifically, land use modifications associated with urbanisation have significantly altered the aquatic environment, resulting in water quality deterioration, additional stormwater and increased flooding. Furthermore, urbanisation exerts a strong influence on the quality of stormwater, which is being increasingly contaminated by a variety of biological, chemical and/or physical pollutants stemming from anthropogenic activities commonly practiced in urban areas (Pitt et al., 1995). Contaminated stormwater constitutes one of the world's main transport mechanisms introducing non-point source pollutants into receiving waters (Pitt et al., 1995).

As a consequence, stormwater quality monitoring has become an essential component in both local and national programmes. Such programmes feature specific objectives, including: sensitivity of receiving waters to stormwater discharges, comprehensive monitoring of targeted pollutants, and source monitoring in order to identify critical sources at the local scale. In Europe, the Water Framework Directive

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(WFD) is an important piece of environmental legislation (EC, 2000), which aims at achieving good ecological and economical status. The WFD defines as a primary objective the prevention of any further deterioration to water sources as well as the protection and enhancement of the status of aquatic ecosystems. A list of 33 priority substances was thus regulated as part of Decision No. 2455/2001/EC issued by the European Parliament and Council. Since 2004, monitoring programs have been implemented for surfaces waters by EU Member States. However, in urban areas, stormwater quality is still poorly addressed as regards many of those substances (Bressy et al., 2011; Björklund et al., 2009; Gasperi et al., 2008).

Urban stormwater quality management however is of critical importance to urban development and water resource planning. Many studies conducted on stormwater quality (Gromaire et al., 1999; Davis et al., 2001; Rule et al., 2006a) have indicated that pollution in stormwater is mainly bound to particles. This latter point is of prime interest both for wastewater treatment plant managers and for river basin management.

To provide data on priority substances in urban areas, Zgheib et al. (2008) established a list of 88 substances (i.e. 65 organic substances, 8 metals and 15 volatile organic compounds), based on the WFD list of priority substances and the adapted version of the Chemical Hazard Identification and Assessment Tool methodology according to Eriksson et al. (2005). This list was adopted in order to evaluate the quality of urban waters (stormwater and wastewater). Besides, Zgheib et al. (2008) developed an innovative methodology to analyse water samples in both the dissolved (D) and particulate (P) phases, because the analyses carried out on unfiltered samples yielded poor quality data on chemical substances, as demonstrated by Zgheib et al. (2008) and Vignati et al. (2009).

This work was performed within the framework of the third phase of the OPUR (Observatory of Urban Pollutants) programme, which sought to improve knowledge of the origin, characteristics and transfer of pollutants in urban catchments during dry and wet weather periods. Two papers from OPUR are being presented in this special issue. The first describes in detail the study undertaken to investigate stormwater quality for the 88 identified priority substances (Zgheib et al., 2008). The discussion focuses on the contamination of stormwater particles. This kind of information is lacking in the literature and our study is one of the first to addressing this issue. The final objective of this paper is to determine the potential impact of stormwater discharges into local watercourses in order to establish whether or not there is a risk to decrease sediment quality. The second paper of the series, contained in this same issue (Gasperi et al., 2012), focuses on the results obtained by applying the same methodology for combined sewer overflows.

2. Materials and methods

2.1. Sampling site

Stormwater quality was monitored on three catchments, all located in Paris and its suburbs (Fig. 1). The sites differed however in terms of land development and housing density.

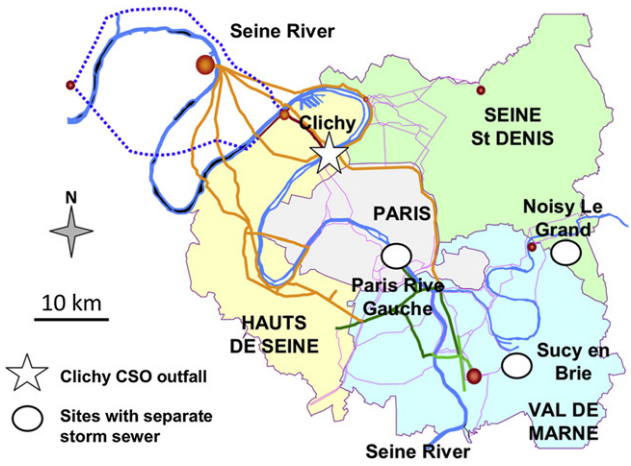

Fig. 1 – Location of the sampling sites. Clichy refers to the largest CSO outfall located in the Paris conurbation (Gasperi et al., 2012).

Sucy-en-Brie (SEB) is a residential area (with 90% of individual dwellings) of 261 ha in size with an impervious surface coefficient (ISC) of 0.27. Noisy-le-Grand (NLG) is a 230-ha urbanized zone (ISC: 0.65), its catchment is typical of a dense urban area (encompassing a commercial centre, apartments, buildings…) with a population of 59,000 inhabitants (i.e. approximately 258 inhabitants/ha). ZAC Paris Rive Gauche (PRG) is a high-density urbanized area covering 130 ha (ISC: 0.80); this is a mixed residential and commercial use area, including also the National Library of France, the Paris 7 Denis Diderot University and some buildings, ultimate architectural testimony of the industrial past of the catchment.

These three watersheds are served by a separate sewer and storm drain. Polluted stormwater is discharged in an untreated state into local watercourses. Our sampling points were located at the storm sewer outlet of each watershed prior to discharge into the receiving waters (Zgheib et al., 2008).

2.2. Sampling procedure

Twenty storms were followed between February 2008 and March 2009: 10 for SEB, 6 on NLG and 4 on PRG. However, due to technical problems, only 16 were analysed for stormwater priority substances. The characteristics of these storms have been summarized in Supporting Table 1. The entire sampling procedure has already been described in Zgheib et al. (2008). In brief, once collected, the samples were filtered to separate the dissolved phase (D) from the particulate phase (P). Analyses were carried out within 24 h for the dissolved phase, while the suspended particulate matter was deep-frozen at −28 °C then lyophilised and analysed after 48 h (Zgheib et al., 2011b).

2.3. Experimental procedure

2.3.1. Routine water quality parameters

Each stormwater sample was analysed for routine water quality parameters (Table 1), such as pH, conductivity, suspended particulate matter (TS), chemical oxygen demand