

Characterization of combined sewer overflows (CSOs) and evaluation of their impacts on urban waters

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Introduction

Untreated or partially treated sewage is a major source of microbiological contaminants at DWIs though the discharge by WWTPs effluents, bypasses and combined or sanitary sewer overflows (CSOs or SSOs). Short-term acute contamination at the water intake is a major factor affecting the likelihood of waterborne outbreaks (Christensen et al., 1997; Commission North Battleford, 2002; Hrudey and Hrudey, 2004). A research project was launched to investigate the causes of such variations at DWIs located on the des Prairies River (Qc, Canada) that only receives CSO or SSO discharges. Early phases of the research project allowed the identification of priority CSOs with the highest potential to impact the DWIs (Madoux-Humery et al., 2009). CSO discharges were then characterized in terms of duration and concentrations of microbial and pharmaceutical indicators (Madoux-Humery et al., 2010).

Objectives

The objectives of this phase of the research are to (1) estimate mass loadings of contaminants in the CSOs studied and model the mass loadings of all upstream CSOs; (2) analyze the seasonal variability of CSO discharges; (3) show the cumulative and short term transient impact of the CSO discharges on water quality in the des Prairies River and at the DWI; and (4) investigate the relationships between pharmaceuticals and *Escherichia coli*.

Methodology

In 2009-10, 16 CSO events were sampled at various periods (spring freshet and summer and fall storm events). Monitoring included flow and duration of discharges, *E. coli*, pharmaceuticals (caffeine and carbamazepine) and physico-chemical compounds (TSS, DOC, P, N & NO₃⁻). Additional monitoring was conducted in the river at nine locations and at two DWIs for 20 dry and 13 and wet weather events. Data on the duration and the frequency of CSO discharges and river flows was consolidated and additional short-term sampling was conducted to monitor the passage of short-term contamination plumes at the DWI.

Results

For one location, CSO events occurred approximately 50 times a year and CSO duration varied between 1 and 16 hours, with an average value of 6 hours. Concentrations of the different compounds varied over a wide range during the discharge and relationships between the various pharmaceutical and microbial indicators and TSS in the CSO as well as in river samples are being investigated. Some results concerning CSO monitoring at one sewage outfall are summarized in Table 1.

Table 1: Flow rate, discharged volume, duration average values of 7 CSO events and *Escherichia coli*, caffeine and carbamazepine average concentrations measured for the first 6 hours of the events. Minimum and maximum concentrations are indicated in brackets.

	Average value (min-max)
Flowrate (L/s)	235 (0.1-3485)
Discharged volume (m ³)	92 (6530-19370)
Duration (hours)	463 (89-926)
[<i>E. coli</i>] (MPN/100mL)	2.5 ×10 ⁶ (5.0 ×10 ³ - 1.5 ×10 ⁷)
[Caffeine] (ng/L)	6734 (292-71311)
[Carbamazepine] (ng/L)	196 (15-1691)

Furthermore, contaminant mass loadings will be calculated and potential sinks of pharmaceuticals and *E. coli* are being investigated by characterization of combined sewer deposits.

River water quality monitoring shows clear gradients of pharmaceutical and microbial contaminant concentrations from upstream to downstream and across the river at specific points in both dry and wet weather conditions. Relationships between the various pharmaceutical and microbial indicators and TSS in the CSO and river samples are being investigated. Caffeine and carbamazepine compounds appear to be excellent tracers to monitor the impact of CSOs in the river and at DWIs, which is most acute during periods of snowmelt and abundant precipitations. Work in progress also includes the estimation of the equivalent volume discharge using the river concentration and flow rate data as applied in Switzerland (Buerge et al., 2006). Event based monitoring at the DWIs allowed for the detection peak contamination that would not have been detected with regular source water concentration characterization. The intense rainfall event (20-80mm) resulted in a short-term increase of 0.5-1 log with regards to *E. coli* and approximately 10 ng/L of caffeine.

Relevance to industry

The estimation of mass loadings will fill data gaps concerning flow, volume, and concentrations of contaminants in CSO discharges. Research results will also provide detailed documentation of the potential of pharmaceuticals to monitor fecal contamination from CSO discharges. Finally, our findings will document the need for event-based sampling to evaluate the susceptibility of DWIs in an urban watershed.

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