Faecal indicator bacteria in combined sewer overflows and in the Seine River.

Claire Thérial, Francoise S. Lucas, Ludivine Lesage, Vincent Rocher, Alexandre Goncalves, Pierre Servais, Jean-Marie Mouchel

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Introduction

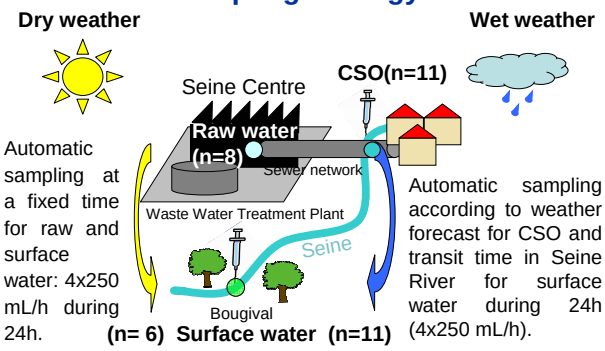
The annual volume of sewage water passing through Paris drainage network is 900 millions m³ of which 25 millions flows without treatment in the Seine River during wet weather. A quarter of these combined sewer overflows (CSO) occurs at Clichy and La Briche outfalls. The importance of these CSOs can degrade the microbiological quality of the Seine River and create sanitary problems.

The goal of this study was to measure the concentrations of faecal indicator bacteria (FIB) in the Seine water after CSOs and to estimate their impact on surface water quality. *Escherichia coli* (EC) and intestinal enterococci (IE), were measured during dry and wet conditions inside the sewer network and in the Seine River at Bougival (fig. 1-2).

Figure 1: The River Seine at Bougival

Material and methods

Sampling strategy



Automatic sampling at a fixed time for raw and surface water: 4x250 mL/h during 24h.

Automatic sampling according to weather forecast for CSO and transit time in Seine River for surface water during 24h (4x250 mL/h).

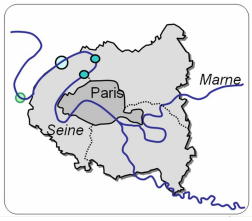
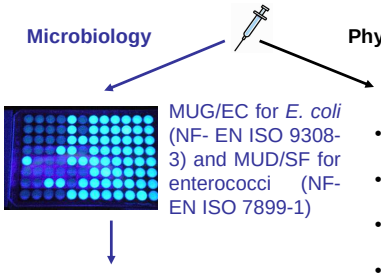


Figure 2: Map of Ile-de-France region. ◯ Seine centre waste water treatment plant raw water, ● sewer outlets Clichy and La Briche CSO, ● Bougival, surface water.

Analysis



Results

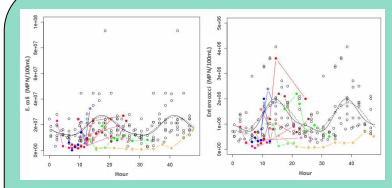


Figure 3: FIB concentration in raw water/CSOs. A: *E. coli*, B: Intestinal enterococci. Black circles for wet weather, colour circles for dry weather. Black line represents sinusoidal adjustment with the first harmonic. Replicated data until 48h for wet weather.

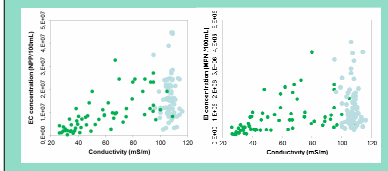


Figure 4: FIB concentration relation with conductivity during wet weather (●) and dry weather (◯).A : *E. coli*, B : Intestinal Enterococci.

CSOs:

- Daily cycles (fig. 3) were observed in raw waters during dry weather for both FIB concentrations depending on human activity.
- During dry weather, the average conductivity of raw water was 107±4 mS/m and lowered during wet weather (fig. 4). Depending on the rain event, FIB concentrations in CSOs also decreased from 2 to 16 fold during wet periods, suggesting a dilution of raw water by runoff water containing low FIB concentrations (fig. 3 and 4).
- FIB concentrations were highly variable in both raw water and CSOs (fig. 4).

Impact of CSOs on surface waters:

- CSO impact was significant at Bougival for NH_4^+ concentration, conductivity and FIB densities (fig.5-6).
- FIB concentrations in surface water increased during rain events, despite the dilution of CSOs in the river water and the sedimentation of TSS and FIB.
- There was no correlation between FIB concentrations and turbidity or TSS concentration (data not shown).

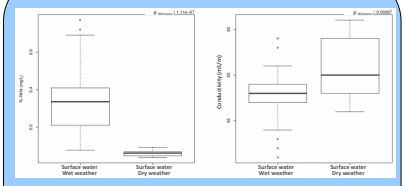


Figure 5: Ammonium concentration and conductivity in surface water during dry and wet periods.

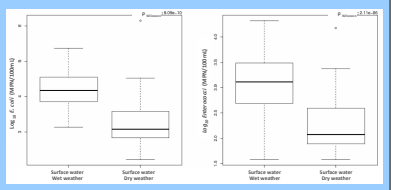


Figure 6: FIB concentration in surface water during dry and wet periods.

Conclusions

During dry periods there was a strong daily cycle for turbidity, TSS, NH_4^+ (data not shown) and IE concentrations in raw water, a weaker one for EC concentrations, and no visible daily cycle for conductivity (data not shown). There was also seasonal variations in the raw water between summer and autumn for NH_4^+ and FIB (data not shown).

For wet periods, dilution phenomenon with runoff water explained the variation of FIB densities, NH_4^+ concentration and conductivity in the CSOs, but not the variation of TSS and turbidity (data not shown). Additional sources of FIB seemed to occur during storm events since there was no significant correlation between FIB and NH_4^+ concentrations (data not shown). This suggests that FIB could be brought by the rain runoff and/or eroded from sewer network. Furthermore, the CSO had a significant impact on the river water quality concerning NH_4^+ and FIB concentrations. However elimination processes of FIB, such as dilution and sedimentation, contributed to lower this impact.

This study should be used to develop a model to predict FIB densities during storm events in surface waters. This model should take into account all the CSOs in the Paris area in order to evaluate at the annual impact of CSOs on the Seine River microbial quality [2].

[1] Jarvis, B., Wilrich, C., and P.-T. Wilrich: Reconsideration of the derivation of Most Probable Numbers, their standard deviations, confidence bounds and rarity values. Journal of Applied Microbiology 109 (2010), 1660 –1667
[2] Modélisation de la contamination fécale en Seine : impact des rejets de temps de pluie. Michel Poulin, Pierre Servais, Jean-Marie Mouchel, Claire Thérial, Ludivine Lesage, Vincent Rocher, Alexandre Goncalves, Sophie Masnada, Françoise Lucas, Nicolas Flipo.

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