



**HAL**  
open science

## **Predicting water quality in urban rivers: Linking high frequency monitoring and spatial rainfall**

Arthur Guillot - Le Goff, Yoann Cartier, Rémi Arthur Carmigniani, Damien Malardé, Mohamed Saad, Philippe Dubois, Thomas Einfalt, Vinçon-Leite Brigitte

### ► **To cite this version:**

Arthur Guillot - Le Goff, Yoann Cartier, Rémi Arthur Carmigniani, Damien Malardé, Mohamed Saad, et al. Predicting water quality in urban rivers: Linking high frequency monitoring and spatial rainfall. 16 th International Conference on Urban Drainage, TU Delft, Jun 2024, Delft, Netherlands. <hal-05045353>

**HAL Id: hal-05045353**

**<https://hal.science/hal-05045353v1>**

Submitted on 24 Apr 2025

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY-ND 4.0 - Attribution - No Derivative Works - International License

# Predicting water quality in urban rivers: Linking high frequency monitoring and spatial rainfall

A. Guillot – Le Goff<sup>1, 2\*</sup>, Y. Cartier<sup>1, 2</sup>, R. Carmigniani<sup>2</sup>, D. Malardé<sup>3</sup>, M. Saad<sup>1</sup>, P. Dubois<sup>1</sup>, T. Einfalt<sup>4</sup>, B. Vinçon-Leite<sup>1</sup>

<sup>1</sup> LEESU, Ecole des Ponts, Univ Paris Est Creteil, Marne-La-Vallée, France

<sup>2</sup> LHSV, Ecole des Ponts, EDF R&D, Chatou, France

<sup>3</sup> NKE Instrumentation, Hennebont, France

<sup>4</sup> hydro&meteo, Lübeck, Germany

\*Corresponding author email: arthur.guillot-legoff@enpc.fr

## Highlights

- New probe for high frequency *in situ* monitoring of dissolved organic matter fluorescence in urban rivers
- Utilization of radar rainfall data and delimitation of urban watersheds to estimate pollutant loadings
- Indicator of hydro-meteorological conditions for pollution early-warning

## Introduction

Urban rivers provide multiple ecosystem services, such as drinking water abstraction, recreation, etc. However, in urbanised areas, surface runoff and wastewater misconnections to the stormwater network, during rainfall episodes lead to pollution of the receiving waterbodies (Suslovaite et al., 2024; Tryland et al., 2011). New high-frequency monitoring methods have been developed to assess pollutant loading. They include measurements of fluorescent dissolved organic matter (FDOM). As part of the European research project FORBATH, new *in situ* FDOM sensors have been deployed in urban rivers, in the Paris region. The area of the urban sub-catchments contributing to the pollutant loading of the river was delineated. Relationships between the FDOM data, spatialized rainfall height and other environmental variables were investigated. The main explanatory variables were identified. The aim of the paper is to present how the dimensionality of the dataset was reduced to a single indicator, explaining the peaks and duration of contamination events.

## Methodology

### Urban watershed delimitation

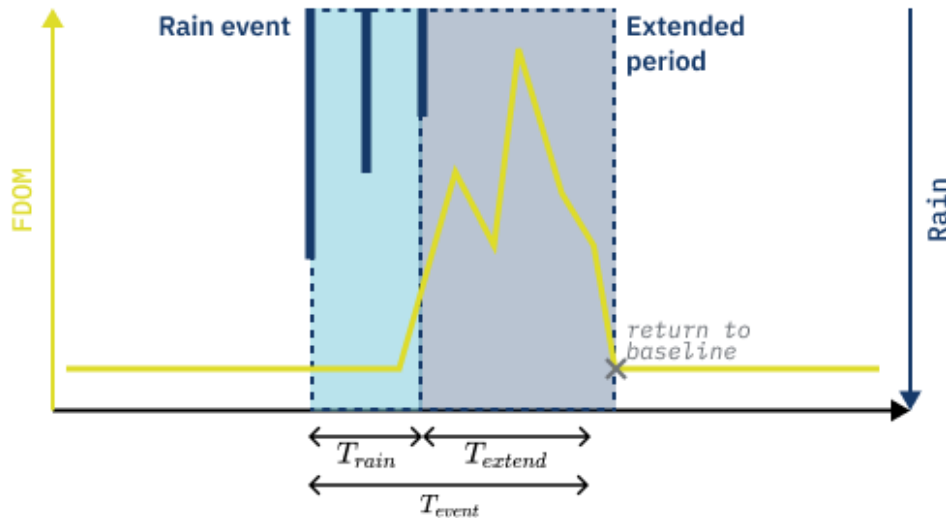
The delimitation of the contributing catchment area is essential for estimating the amount of rainwater that flows through a drainage network before being discharged into the river. In densely urbanised areas, such as the Île-de-France region, it is necessary to take into account the stormwater network (Braud and Branger, 2022; Respaud-Médous, 1999). An existing methodology (Braud et al., 2011) originally developed for a catchment area of 4.1 km<sup>2</sup>, was adapted to cover a much larger catchment area of 88 km<sup>2</sup> in the present study. Data from a digital terrain model, land use, hydrography, and local urban plans for sewage network details were gathered. The step-by-step process includes restricting the study area to topographic watersheds, determining slope directions, overlaying sewage network maps, and identifying drainage areas based on stormwater discharge locations.

### Spatialised rainfall

Rainfall radar data from the Trappes meteorological station (Météo-France) have been calibrated using Météo-France and Seine-Saint-Denis rain gauges. Corrections for blocked beams have been made. The processed radar data provide the rain height with a five-minute time step over pixels around 0.2 km<sup>2</sup>. This spatial dataset is then recomposed into time series of mean rain height over each urban sub-watershed with a one-hour time step.

### Event-based approach

52 The periods of interest were classified into two types: dry periods with minimal precipitation and rainy  
 53 periods with important precipitation. The full extent of the meteorological events and their hydrological and  
 54 contamination impacts was considered. The total event period,  $T_{event}$ , was defined by the rain period,  $T_{rain}$ ,  
 55 extended by  $T_{extend}$  to cover the peak contamination, which generally occurs after the rain has stopped. This  
 56 comprehensive approach includes the FDOM rise and fall to the baseline during a contamination episode  
 57 (see Figure 1).



58  
59

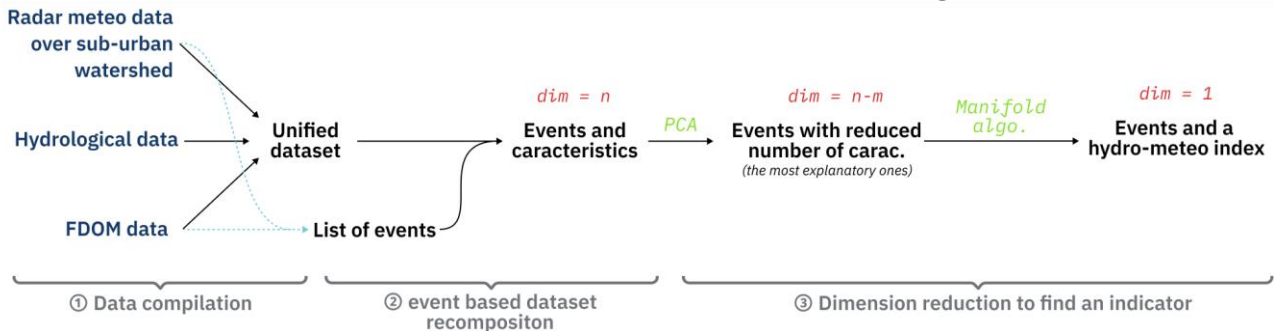
Figure 1 - Schematic definition on an event duration based on rainfall and FDOM intensity data

60 From the timeseries, corrected and synchronized (see Figure 2, step ①), an event can be defined according  
 61 to its meteorological and hydrological characteristics (see Figure 2, step ②).  
 62

63

### Construction of a single explanatory variable

64 Two approaches were used to reduce the dimensionality of the data. First, the most important explanatory  
 65 variables were identified using principal component analysis (PCA). The latter variables were then  
 66 transformed into a single indicator using a non-linear statistical algorithm. Two nonlinear dimensionality  
 67 reduction manifold algorithms were applied and compared (see Figure 2, step ③).



68  
69

Figure 2 – Event-based approach for reducing dataset dimensionality flowchart

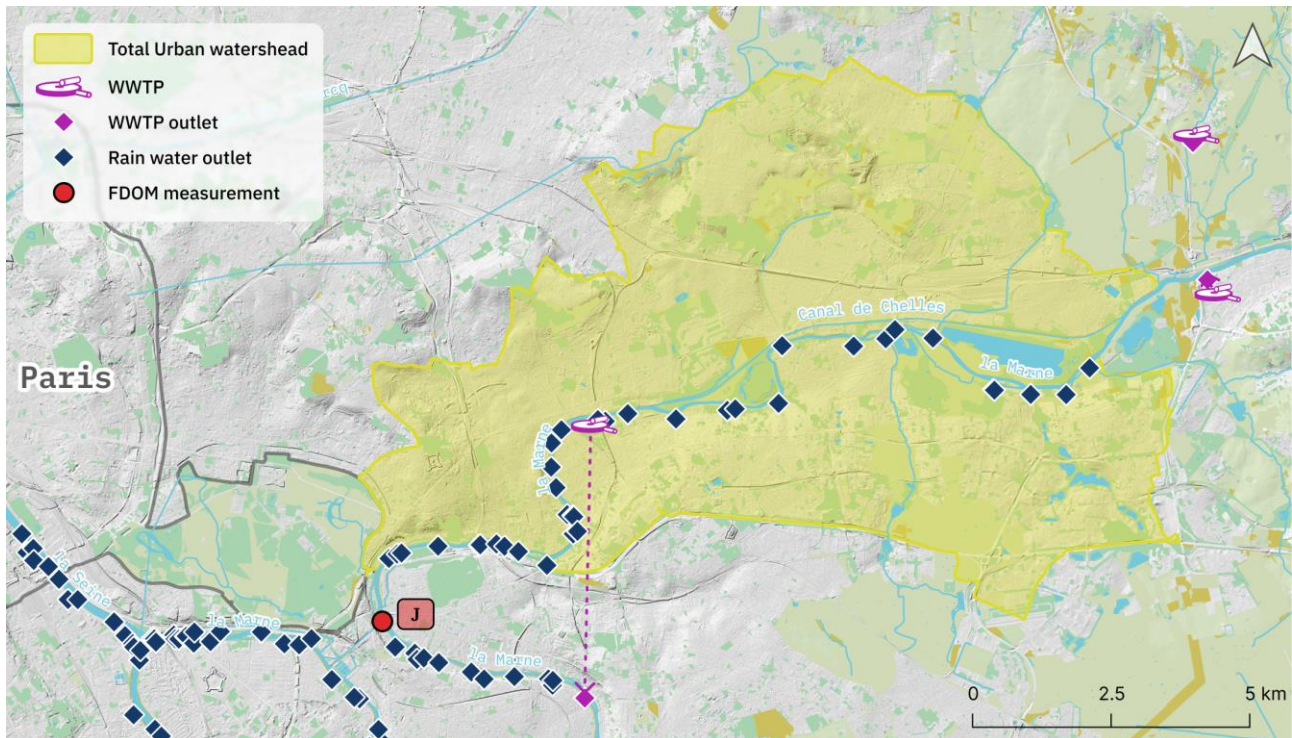
## 70 Case study

71 The study site is a stretch of the Marne river, close to its confluence with the Seine river (Figure 3). An FDOM  
 72 sensor, developed by NKE Instrumentation, has been deployed at point J (Joinville-le-Pont) since October 20<sup>th</sup>  
 73 2023. Point J is located 2.5km upstream an in stream bathing site planned to be open in 2025 as Paris  
 74 Olympics and Paralympics games legacy. Other variables, temperature, dissolved oxygen, conductivity,  
 75 ammonium, nitrates are also measured at the same point at a 20-minute time step.

76

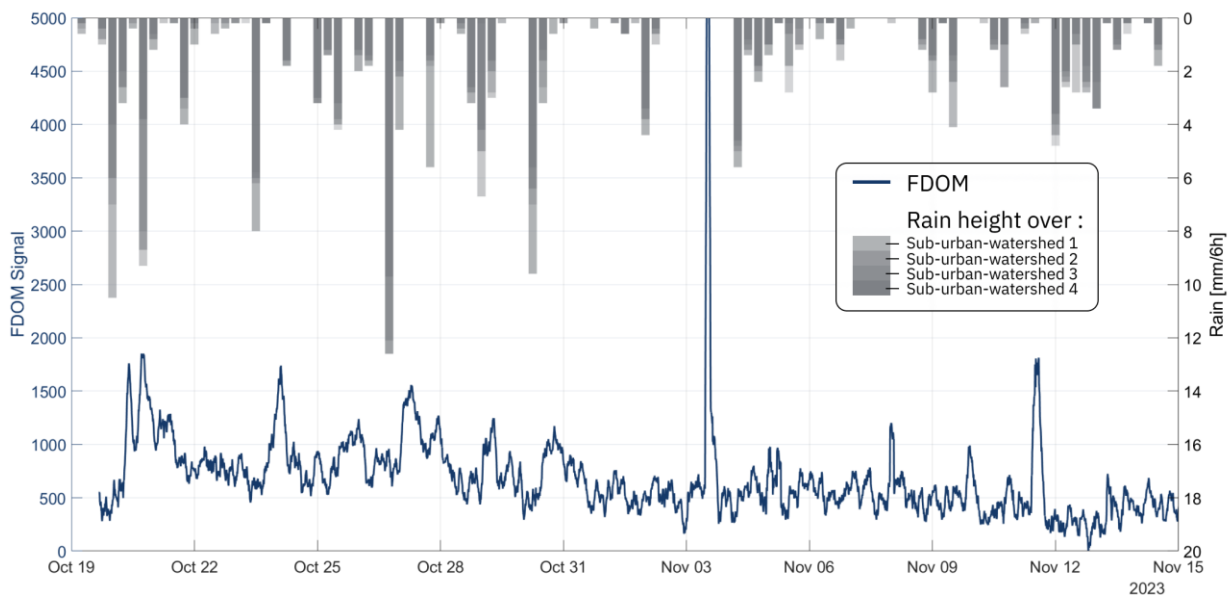
## 77 Results and discussion

78 The watershed upstream of the monitoring point (point J) was delimited. It covers 88 km<sup>2</sup>, 19 km of the  
79 Marne river and it includes 34 stormwater outlets (Figure 3). This area has been divided into sub-urban  
80 watersheds where the mean spatial rainfall has been computed as illustrated in Figure 1.  
81



82  
83 **Figure 3 - Map of the delimited urban watershed and rain water outlet or WWTP outlet along the Marne river**

84 As shown in Figure 4 the FDOM signal and rain data are generally related, with higher FDOM signals  
85 corresponding to higher rainfall. This supports the hypothesis that the sensor correctly detects storm water  
86 discharges. The time between maximum rain intensity and peak FDOM varies from 1 to 10 hours, depending  
87 on the spatial distribution of the rain. Likewise, the intensity of the FDOM peaks varies between 1000 and  
88 2000 arbitrary units. Focusing on these spatio-temporal variations in rainfall and FDOM, and characterizing  
89 each event, make it possible to evaluate the impact of sub-urban watersheds on water quality in the Marne  
90 river.



91  
92 **Figure 4 - FDOM Signal and Rain over sub-urban watershed data for the period of October 19, 2023 to November 15, 2023**

## 93 Conclusions and future work

94 The final aim is to provide an adaptive and easy to implement indicator for water managers. The single hydro-  
95 meteorological index proposed in this paper can be used as a warning indicator of an episode of  
96 contamination. Based on the link between meteorological characteristics and contamination episodes, the  
97 method is useful for targeting field measurement under extreme rain events. Finally, the developed method  
98 may be adapted to identify urban sub-catchments most likely to contribute to a contamination episode.  
99

## 100 References

- 101 Braud, I., Branger, F., 2022. Hydrologie et anthropisation, in: OTHU – GESTION DES EAUX PLUVIALES EN VILLE. GRAIE.  
102 Braud, I., S. Jankowfsky, F. Branger, 2011. Délimitation d'un bassin versant périurbain et identification de son réseau de drainage.  
103 INRAE.  
104 Respaud-Médous, A., 1999. Le système bassin-versant urbain et le problème de ses limites. *rgpso* 4, 77–84.  
105 <https://doi.org/10.3406/rgpso.1999.2708>  
106 Suslovaite, V., Pickett, H., Speight, V., Shucksmith, J.D., 2024. Forecasting acute rainfall driven E. coli impacts in inland rivers based  
107 on sewer monitoring and field runoff. *Water Research* 248, 120838. <https://doi.org/10.1016/j.watres.2023.120838>  
108 Tryland, I., Robertson, L., Blankenberg, A.B., Lindholm, M., Rohrlack, T., Liltved, H., 2011. Impact of rainfall on microbial  
109 contamination of surface water. *Int J of Cl Chan Strat and Man* 3, 361–373. <https://doi.org/10.1108/17568691111175650>