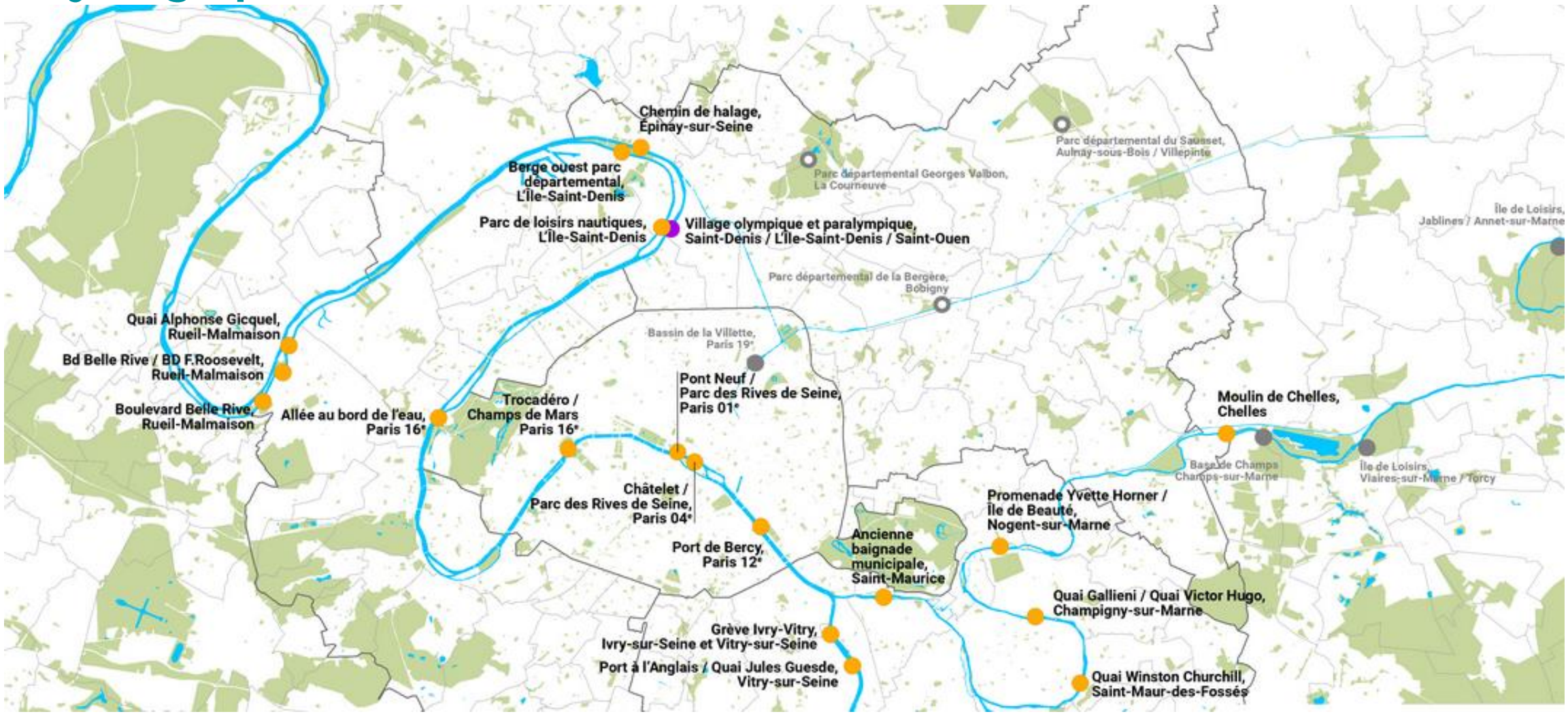
DURL Project
Water Quality in Urban Rivers Conference

# Improving the quality of the Seine: A focus on disconnections and misconnections

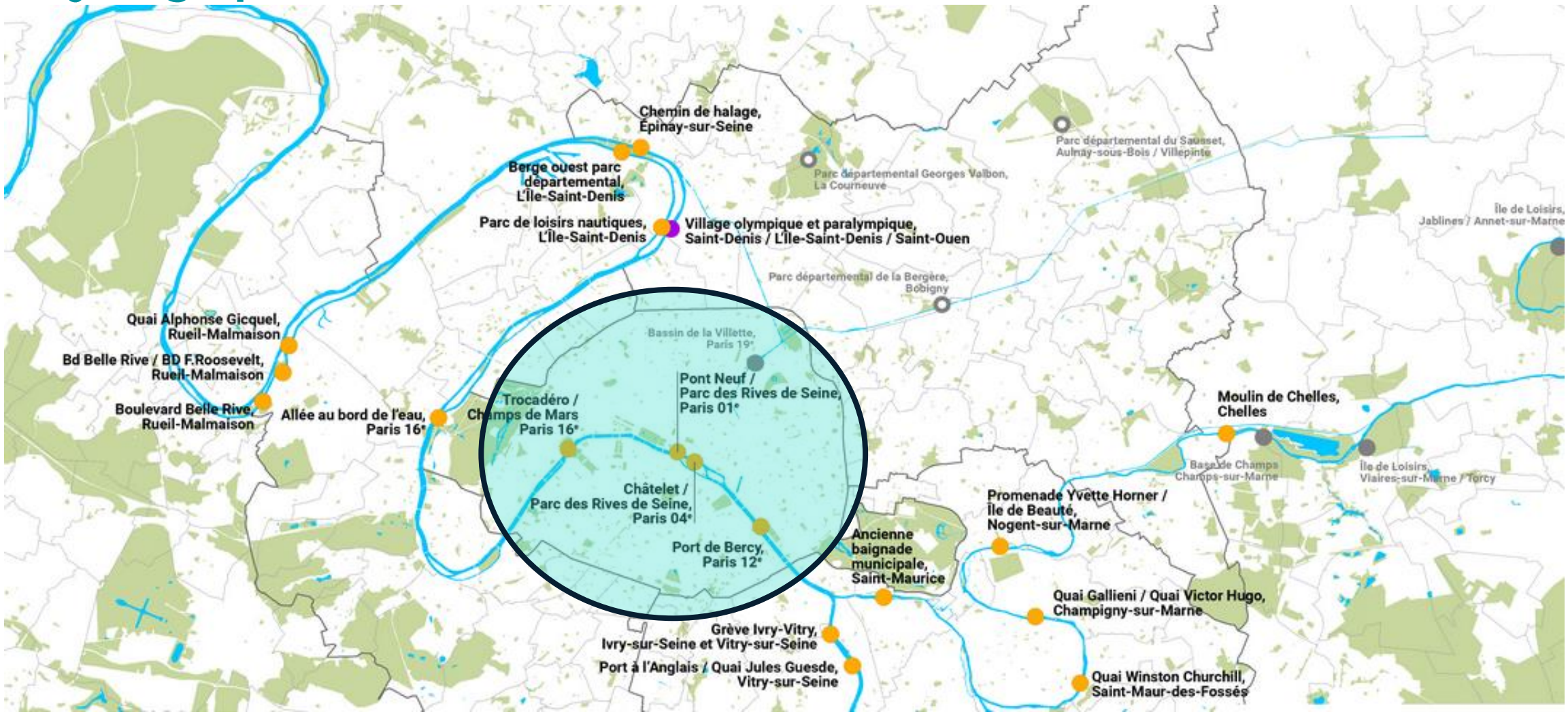
**Paul KENNOUCHE**
**Head of the water quality unit**
**Cleanliness and Water Department – City of Paris**

# Reinventing the Seine :
# Swimming in the Seine in 2025,
# a legacy of the Olympic and Paralympic Games

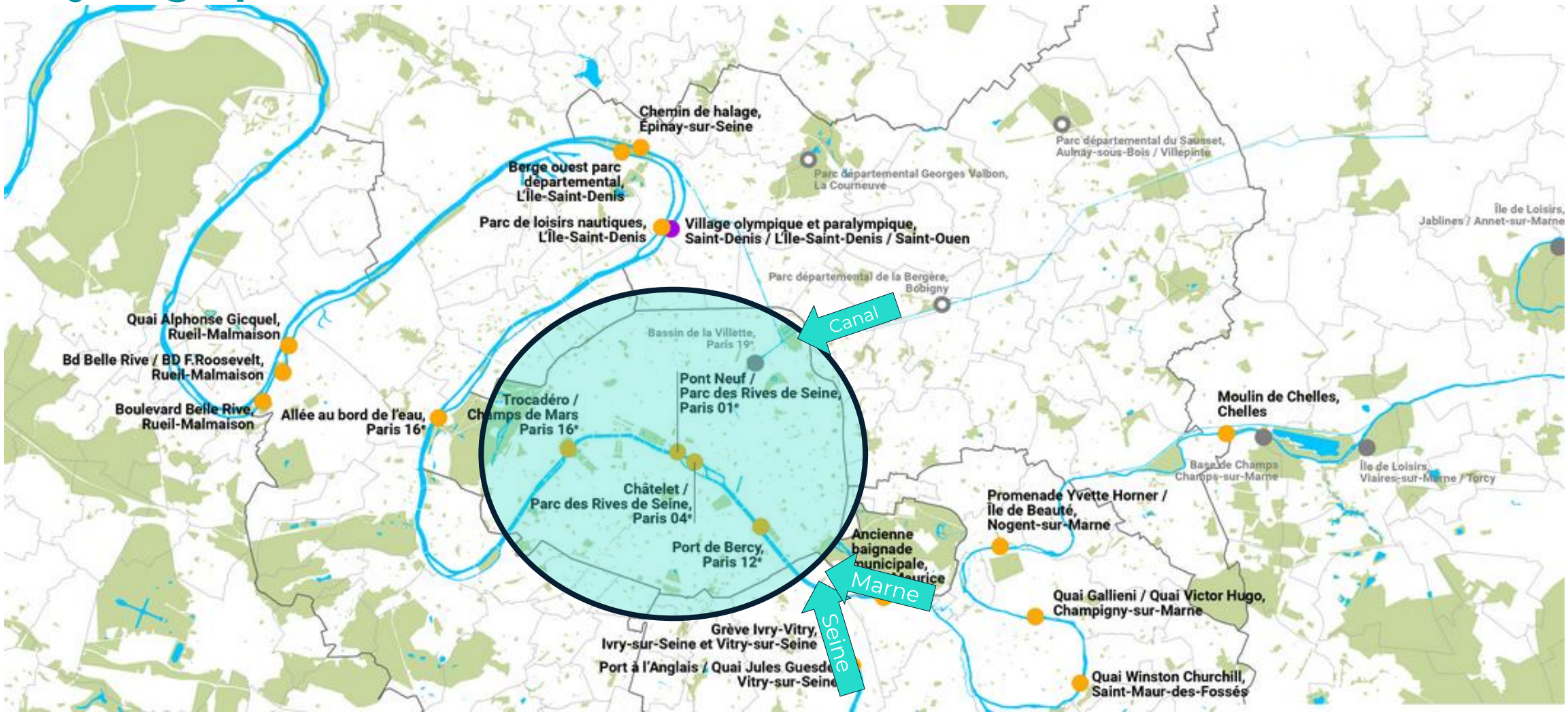
# Hydrographic context



# Hydrographic context



# Hydrographic context



# Leadership towards the water quality action plan

## Meeting water quality requirements in view of the Olympic and Paralympic Games 2024

Initiated in 2016, a complex governance structure

- Steering committee led by the Mayor of Paris and the Prefect of the Ile-de-France Region
- 30 stakeholders
- 6 Working Groups
- 50 actions (rainy/dry weather)

**2015**
***Candidacy for the 2024 OPG***

**2016**
***Call of interest***
*23 bathing areas*
*5 located in Paris*

**2018**
***Water quality action plan approval***
*Signature by the 25 partners*

**2018-2021**
***50 actions launched***
*Knowledge*
*Treatment plants*
*Communication*
*Misconnections*
*Stormwater management*
*Boats discharge*

**2023**
***Bathing in the river Marne***
*Go on with the 50 actions*
*100% of actions lauched*

**2023**
***Actions to be accelarated***
*Collection and misconnections*
*Discharge when raining*
***Pre-Olympic events in the Seine***

**2024**
***2024 OPG***
*Swimming events in open water*

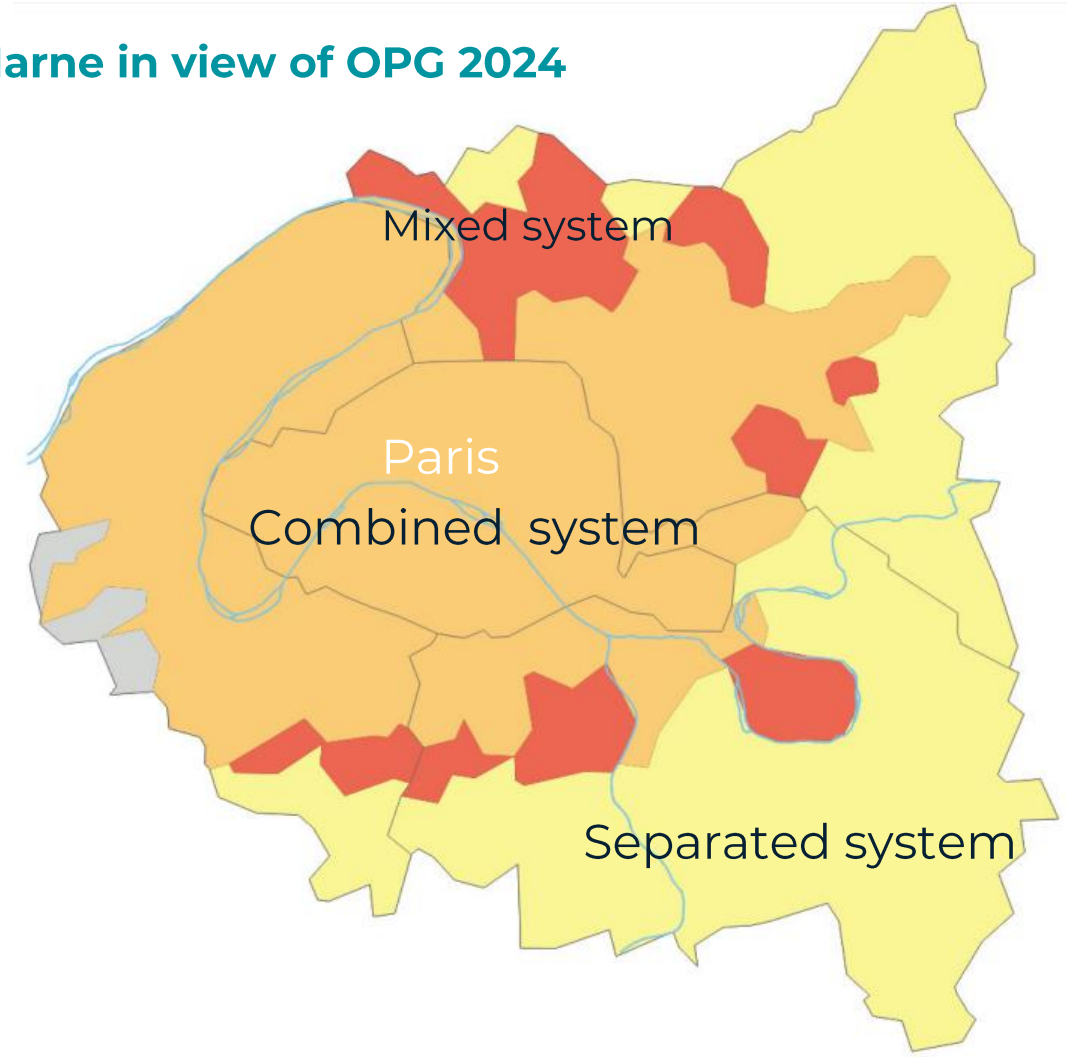
**2025**
***Legacy***
*Bathing for all*

# Bathing in the Seine river Project

## Action plan for achieving water quality in Seine and Marne in view of OPG 2024

Main lines of action:

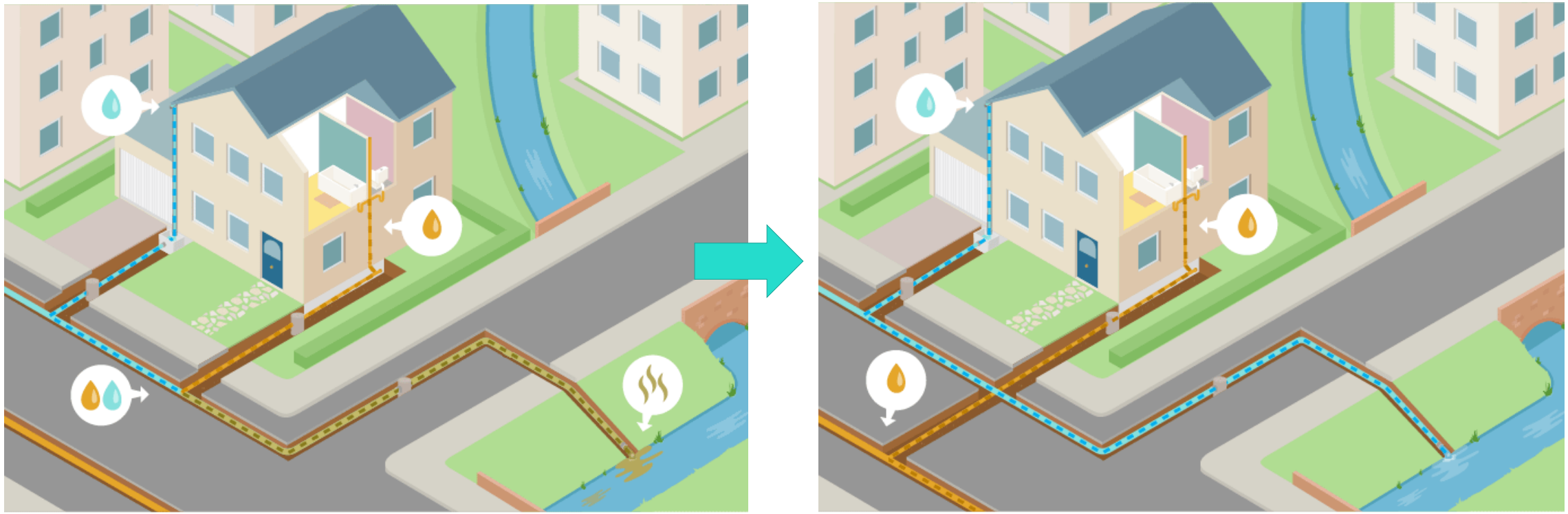
- Improving knowledge of water quality
- Reducing contamination from treated wastewater
- Reducing discharge of untreated wastewater from boats
- **Reducing discharge of untreated wastewater during dry weather periods**
- **Reducing discharge of untreated wastewater during rainy periods**



# Fixing misconnections :
# One of the most ambitous actions

# Bathing in the Seine river Project

## Reducing discharge of untreated wastewater during dry weather periods



# Bathing in the Seine river Project

## Reducing discharge of untreated wastewater during dry weather periods

Objective : suppression of 25 000 misconnections

- Wastewater into rainwater network
- Rainwater into wastewater network

A communication campaign and dedicated website : monbranchement.fr

# Bathing in the Seine river Project

## Reducing discharge of untreated wastewater during dry weather periods

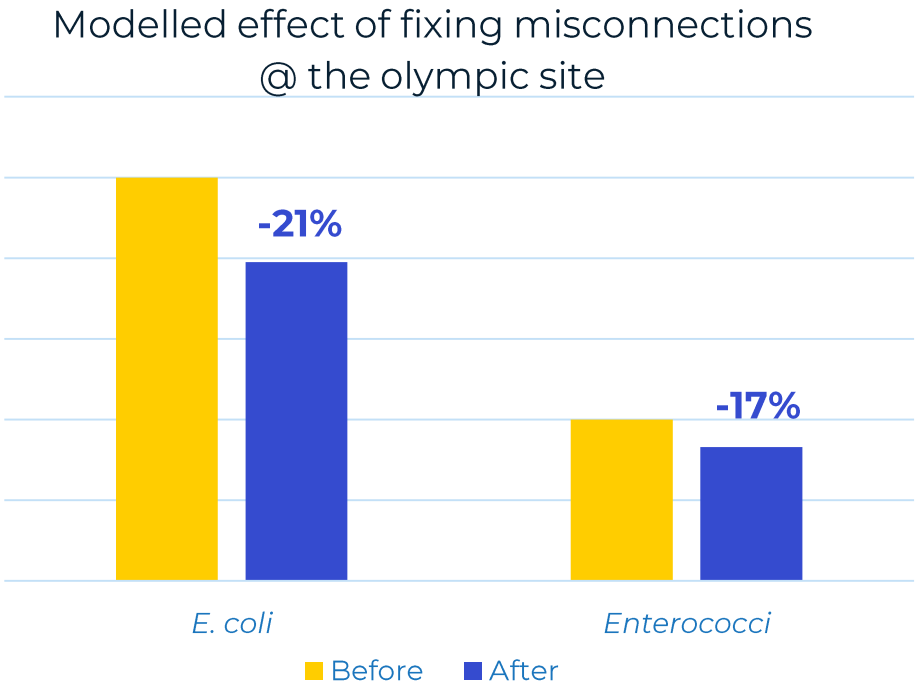
Several lines of actions as incentive :

- 2018 Olympic law : mandatory compliance certificate to allow real estate transactions
- Public buildings, hotels : systematic controls
- Public subsidies : 4200€ for works in individual houses and 420€/inh. in collective housings
- Additional subsidies : by the City of Paris to most vulnerable territories

# Bathing in the Seine river Project

## Reducing discharge of untreated wastewater during dry weather periods

We’ve reached approximately half of the objective.



# Disconnections :
# The example of the LIFE Adsorb project

# Objectives

## An innovative filter reducing pollution from roadwaters to the environment (2019-2025)

**3 objectives**:

- Reducing pollution rejected to the Seine by 95%,
- Testing an innovative system to treat roadwaters,
- Integrating the system in a classified natural site and increase its biodiversity.

# Context

## The vertical reed bed filters (RBFs)


*Location of the RBFs*

**Location**:
West of Paris: Bois de Boulogne park

**RBF catchment area in rainy weather**:
2,6 km of the ring road = 21,1 Ha
Dense roadways (200 000 vehicles/d)
+
Unitary catchment (72 Ha)

**+ dry weather**: uncontaminated groundwater
~56 % of water supplied to RBFs

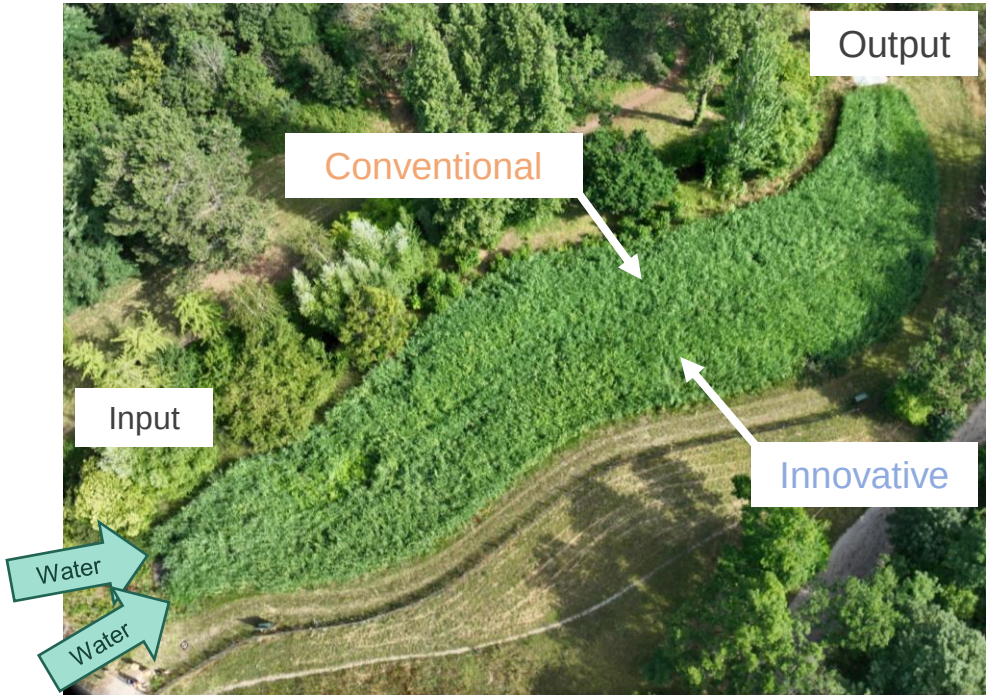
➔ Special hydraulic operation

Ring road → RBFs → Seine

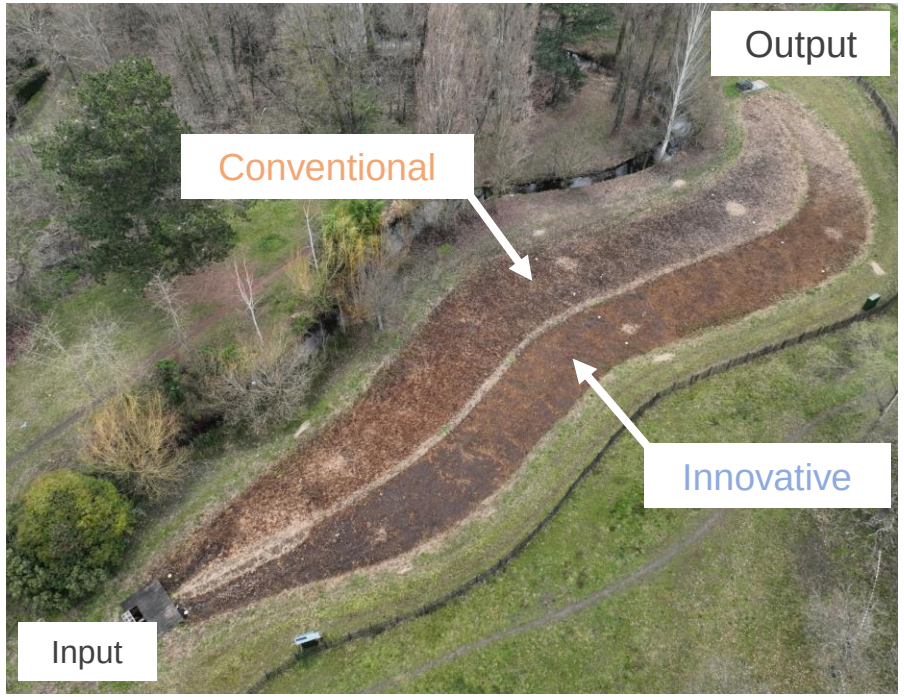
Slide adapted from Dr. Julia ROUX

# Material & Methods

## The vertical reed bed filters (RBFs)




*Summer*




*Winter*

<u>Two RBFs</u>
**Conventional**: 680 m²
**Innovative**: 610 m²

➔ Supply via an **upstream pipe**

Slide adapted from Dr. Julia ROUX

# Material & Methods

## Composition of the RBFs

**Similar conception:**

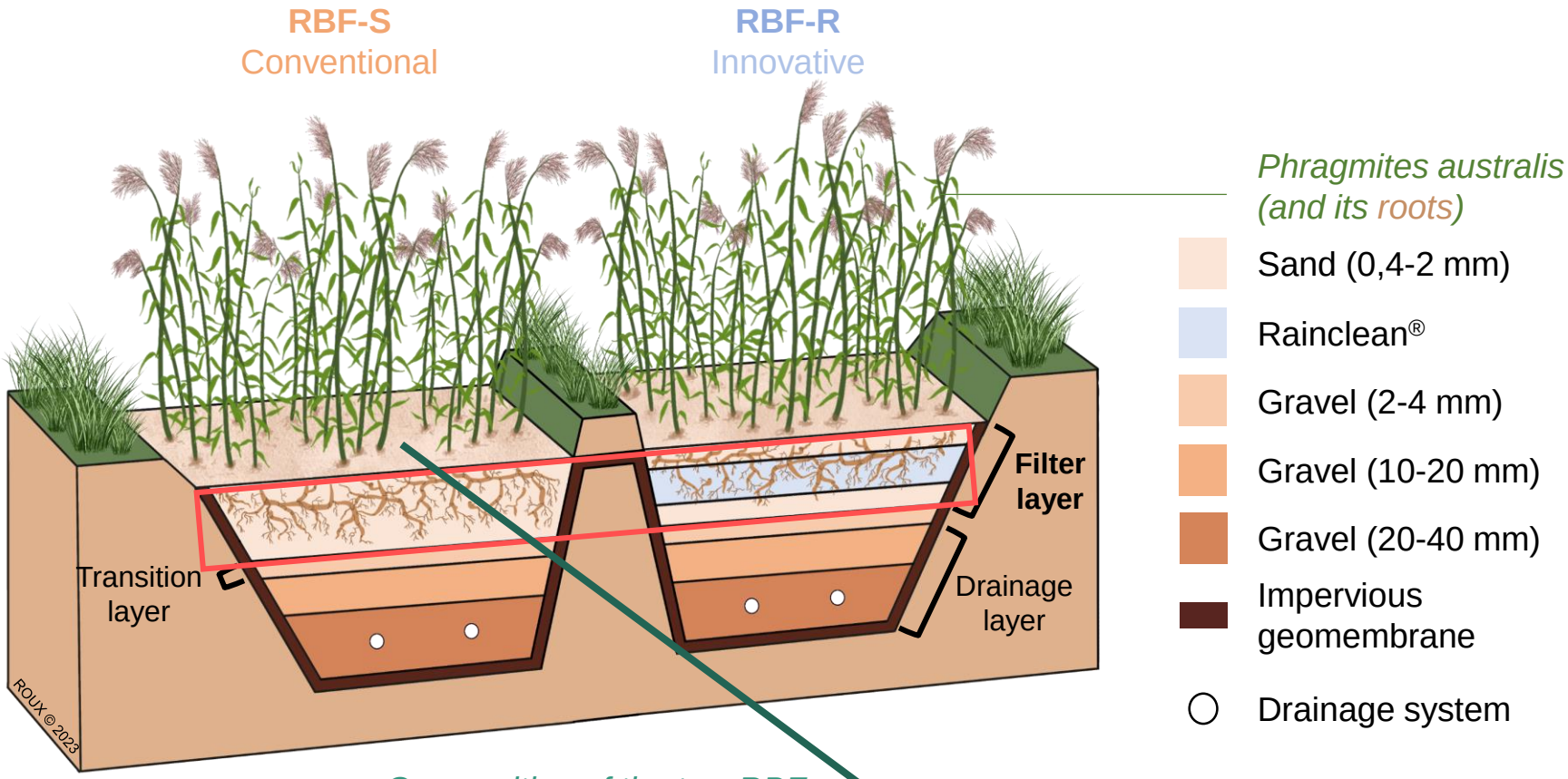
Filter layer : **40 cm**
Transition layer: 10 cm
Drainage layer: 50 cm
Planted with ***P. australis***

**Different composition:**

RBF-S: **Sand** (40 cm)

RBF-R: Sand (10 cm)
**Rainclean®** (20 cm)
Sand (10 cm)

Industrial **adsorbent** substrate:
Carbonates, coconut fibers, pumice stones, zeolites, activated charcoal...




*Composition of the two RBFs*

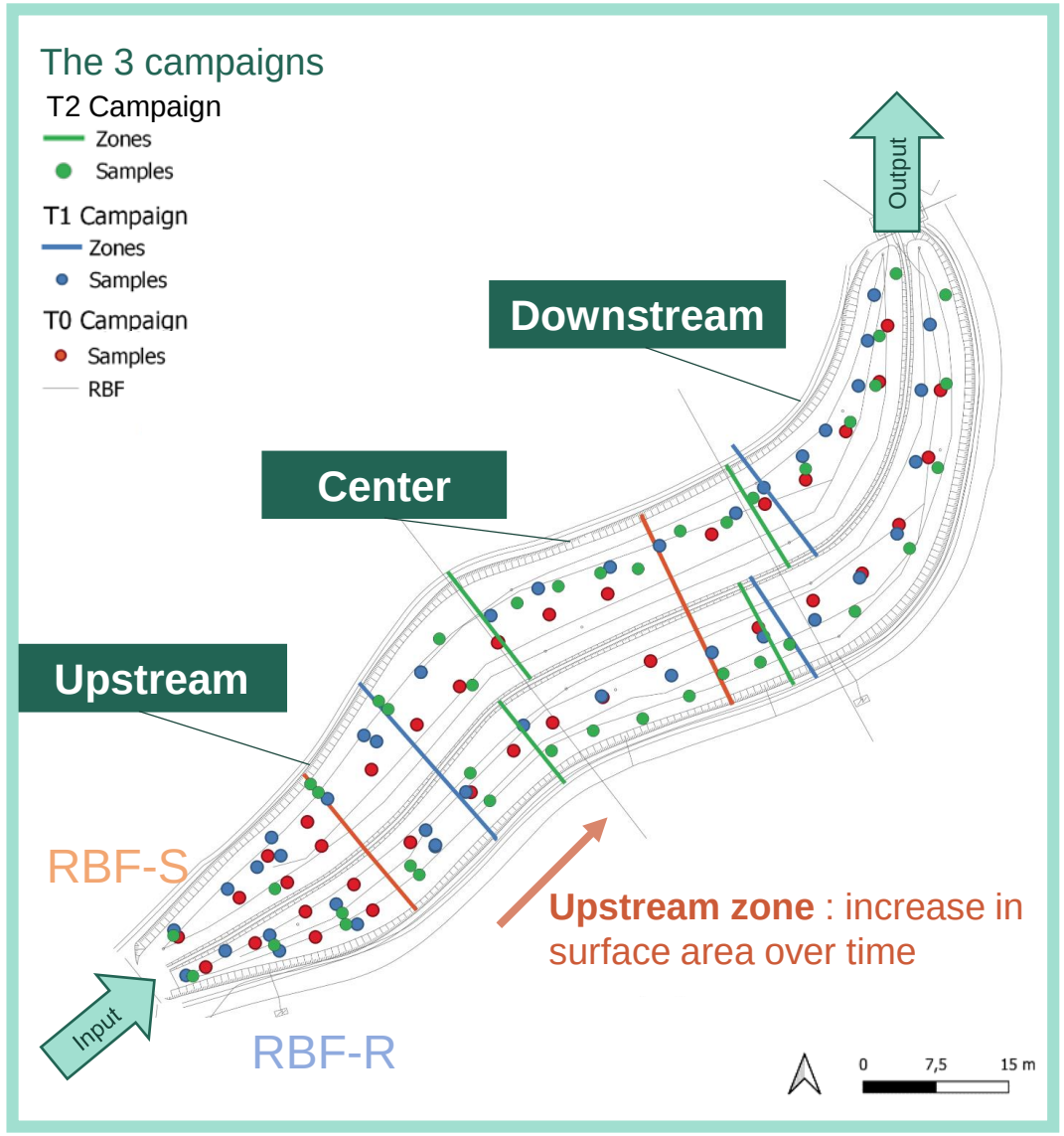
+ Over time: accumulation of **sediment** on the surface

**3 substrates studied:** sand, Rainclean (Rc) and sediment

Slide adapted from Dr. Julia ROUX

# Material & Methods

## Substrates sampling campaigns

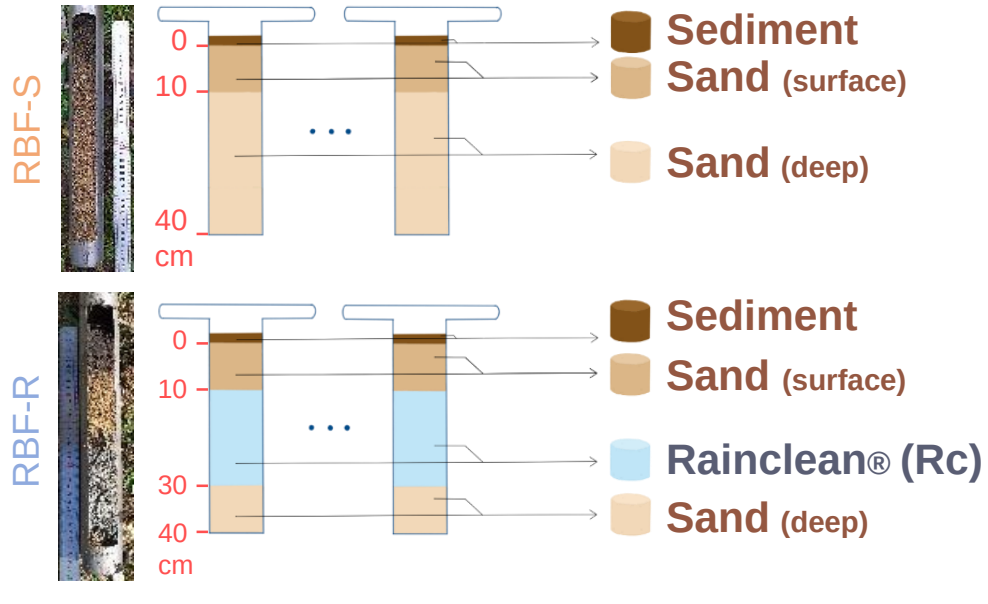



*Sampling campaigns*

**3 campaigns: 2020, 2021, 2022 (sept-oct)**
**3 zones: According to surface condition**

= 1 core sample (40 cm)

**6 to 8 cores/zone**




The different substrates


**Composite samples: N=43**

- Campaign (T0, T1, T2)
- Filter (RBF-S, RBF-R)
- Horizontal location(Up, C, Do)
- Vertical location (substrates)

Slide adapted from Dr. Julia ROUX

# Material & Methods

## Substrate analysis: space-time evolution of the RBFs

### Physico-chemical properties

pH, CEC, particule size, TOC, N, C/N, CaCO3, density, moisture …

+ fine mapping of **sediment** thickness and trace metals

### Trace metals (TMs)

Cd, Cr, Cu, Ni, Pb, Zn

*Aqua regia + ICP-AES*

### Organic micropollutants (OMPs)

PAH, HC index, **Bisphenol-A, Alkylphenols**

*Extraction + UPLC-MS-MS or GC-MS*

### Microbial communities

Bacterial and fungal abundance (*MPN*)

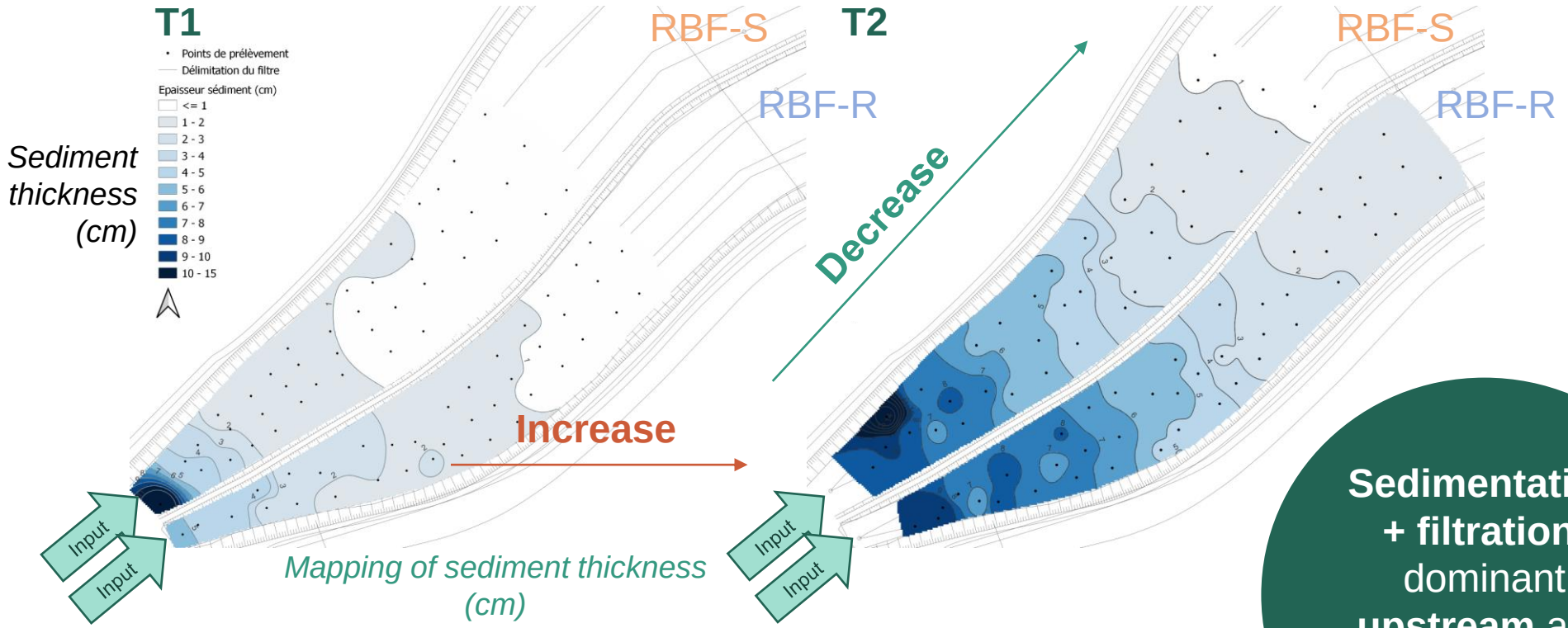
Functions (*Enzymatic activities and Biolog EcoPlates®*)

Genetic diversity (*Illumina Mi-Seq 16S and 18S*)

Slide adapted from Dr. Julia ROUX

# Results & Discussion

## Evolution of RBFs: Sediment accumulation (upstream zone)




*Mapping of sediment thickness (cm)*

**Sedimentation + filtration**: dominant **upstream** and **surface** processes

➔ **Decrease** with distance: 12 to < 2 cm from 30 m

➔ **Increase** with time

➔ **Sediment** exclusively upstream : **32-42%** of total RBF surface at T2

➔ Average annual accumulation rate: **4,1 m³/y** (± 0,37)

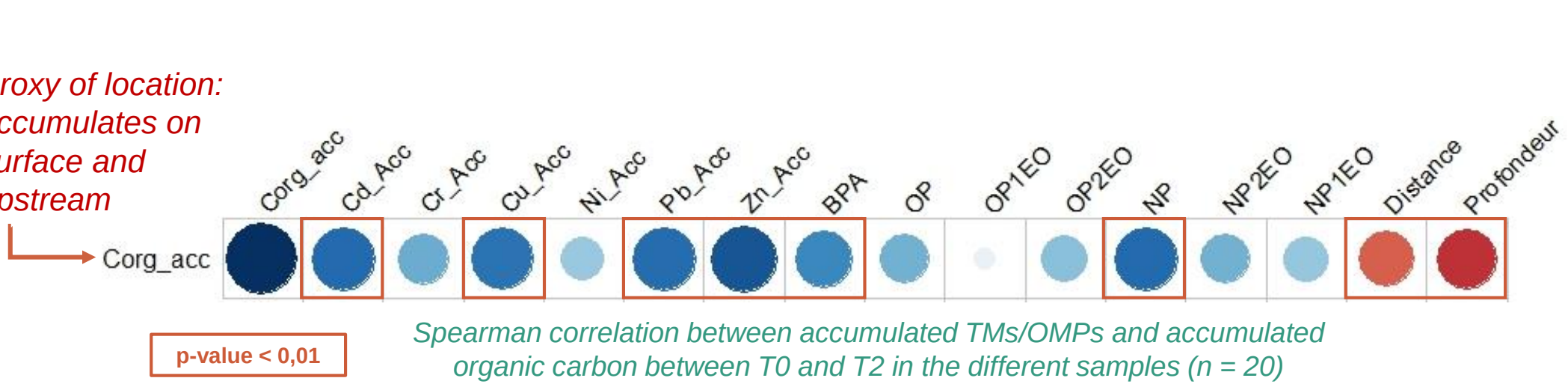
Slide adapted from Dr. Julia ROUX

# Results & Discussion

## Evolution of RBFs: Accumulation of micropollutants after 2 years of operation (T2)

### Spatial Evolution: Correlations between accumulated OMPs/TMs and accumulated organic carbon

*Proxy of location: accumulates on surface and upstream*




**p-value < 0,01**

*Spearman correlation between accumulated TMs/OMPs and accumulated organic carbon between T0 and T2 in the different samples (n = 20)*

Correlation: **r between 0.65 and 0.85**

➔ Most micropollutants = associated with particles + low mobility (except Ni and Cr)
➔ **Sedimentation and filtration** ➔ sediment and surface sand upstream

➔ Water supply and micropollutant properties = **Spatial heterogeneity** of accumulation

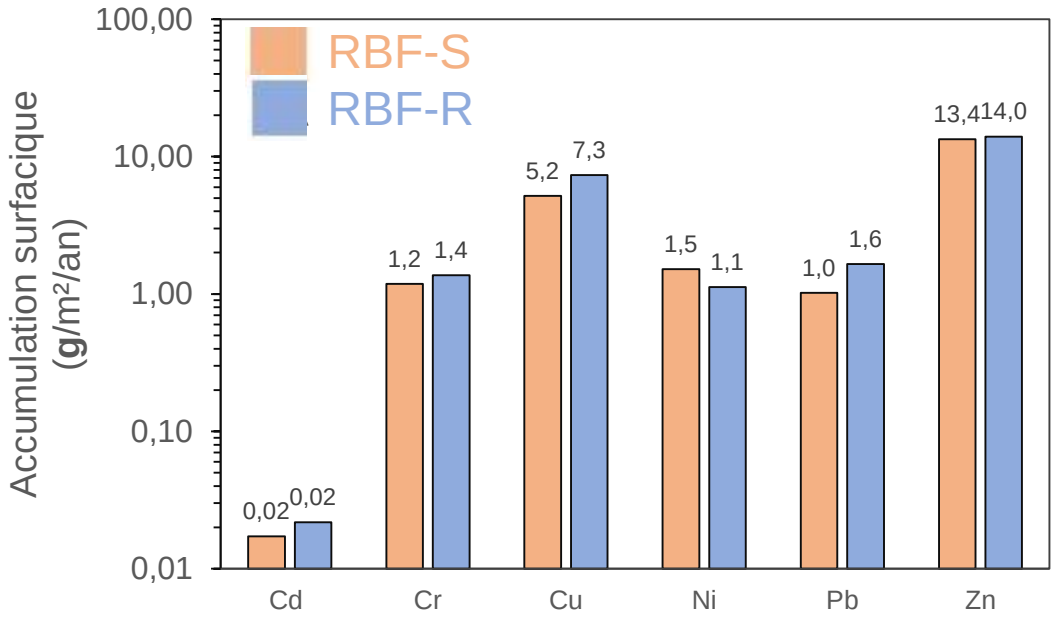
Slide adapted from Dr. Julia ROUX

# Results & Discussion

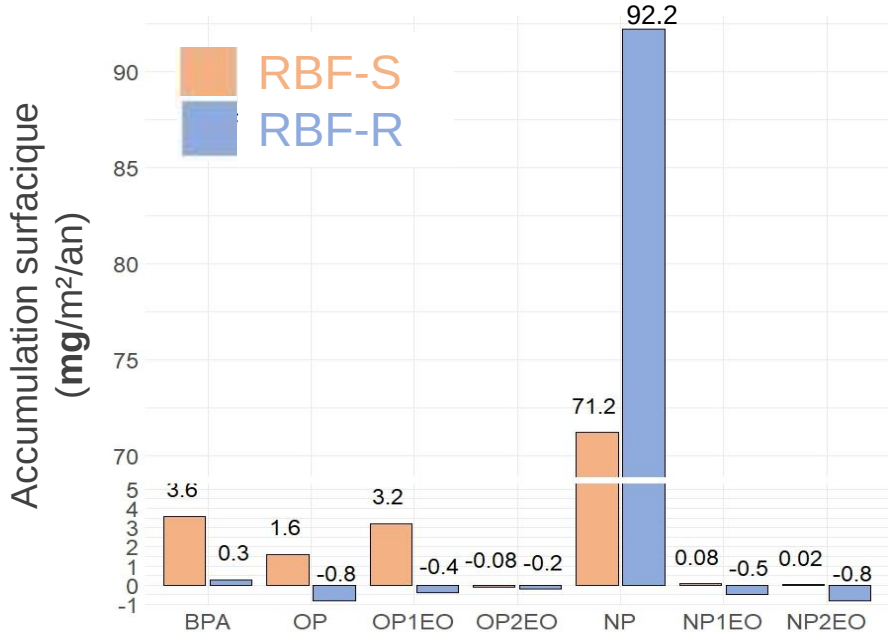
## Evolution of RBFs: Annual accumulation at the RBFs level

### Accumulation rates between T1 and T2

RBFs comparison: surface ratio




*Surface accumulation (**g/m²/year**) of TMs on the scale of RBFs*




*Surface accumulation (**mg/m²/year**) of OMPs on the scale of RBFs*

**TMs accumulation > OMPs (only 4-NP)** : similar to runoff water quality *(Flanagan et al., 2018 ; Gasperi et al., 2022)*
+ dissipative processes for OMPs only *(Lefevre et al., 2012)* ➔ *BIODEGRADATION*

**TMs** : Slight differences in accumulation between the 2 RBFs
**RBF-R vs RBF-S** : **Limited role of Rc** after 2 years

Slide adapted from Dr. Julia ROUX

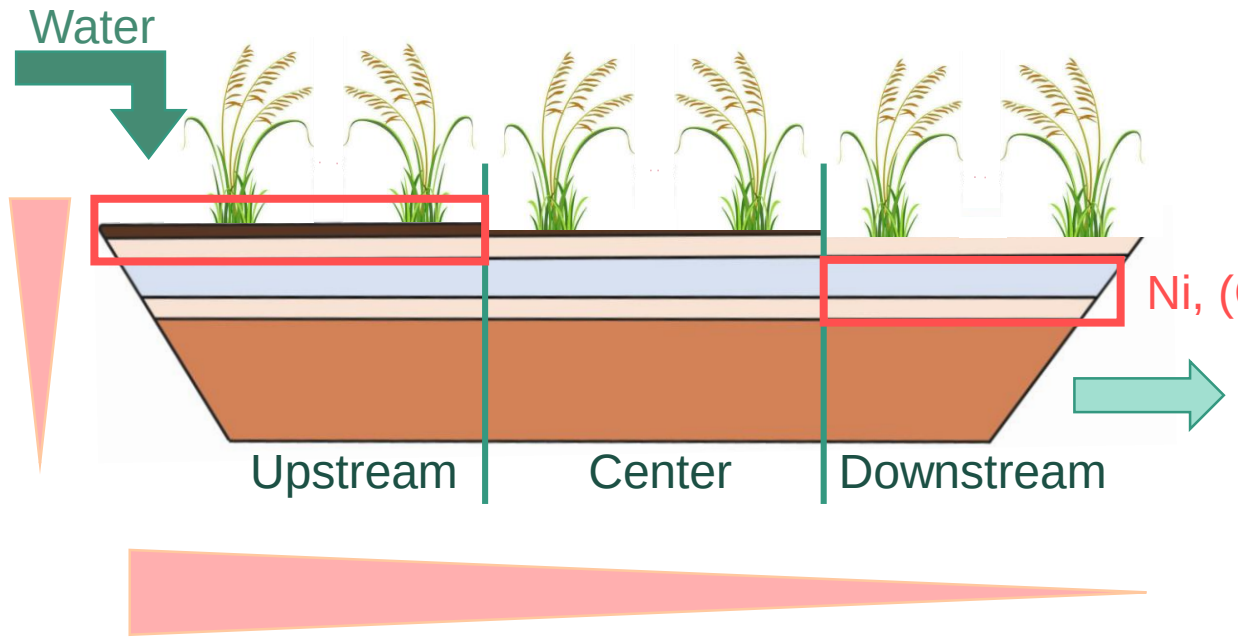
# Conclusion

## Micropollutant retention processes

**Sedimentation and filtration dominate + Adsorption of OMP in sediment**

TM (g/m²/y) (Zn dominates) > OMP (mg/m²/y) (4-NP dominates)

Spatial heterogeneity of contamination:
Cd, Cu, (Cr, Ni), Pb, Zn, 4-NP, BPA




Limited role of Rc at RBF level

Water quality required

After 2 years of operation: Sediment only layer considered as polluted

➔ Sand monitoring within 3 to 6 years (upstream)

➔ Plants can be composted (green waste)

Slide adapted from Dr. Julia ROUX

# Olympic and paralympic Games

## July-September 2024


PARIS 2024

# 2025 Legacy bathing

# References


El Mekdad, F., N. Nunan, S. Abiven, et X. Raynaud. « Enzyme Activities Down the Soil Profile: A Meta-Analysis ». SSRN Scholarly Paper. Rochester, NY, 2022. https://doi.org/10.2139/ssrn.4239557.

Flanagan, K., P. Branchu, L. Boudahmane, E. Caupos, D. Demare, S. Deshayes, P. Dubois, et al. 2018. « Field Performance of Two Biofiltration Systems Treating Micropollutants from Road Runoff ». *Water Research* 145: 562-78. https://doi.org/10.1016/j.watres.2018.08.064.

Gasperi, J., J. Le Roux, S. Deshayes, S. Ayrault, L. Bordier, L. Boudahmane, H. Budzinski, et al. 2022. « Micropollutants in Urban Runoff from Traffic Areas: Target and Non-Target Screening on Four Contrasted Sites ». *Water* 14 (3): 394. https://doi.org/10.3390/w14030394.

Guo, C., J. Li, H. Li, et Y. Li. « Influences of Stormwater Concentration Infiltration on Soil Nitrogen, Phosphorus, TOC and Their Relations with Enzyme Activity in Rain Garden ». *Chemosphere* 233 (2019): 207-15. https://doi.org/10.1016/j.chemosphere.2019.05.236.

Jiang, C., J. Li, H. Li, et Y. Li. « Nitrogen Retention and Purification Efficiency from Rainfall Runoff via Retrofitted Bioretention Cells ». *Separation and Purification Technology* 220 (2019b): 25-32. https://doi.org/10.1016/j.seppur.2019.03.036.

LeFevre, G. H., R. M. Hozalski, et P. J. Novak. 2012. « The role of biodegradation in limiting the accumulation of petroleum hydrocarbons in raingarden soils ». *Water Research*, Special Issue on Stormwater in urban areas, 46 (20): 6753-62. https://doi.org/10.1016/j.watres.2011.12.040.

Mkhinini, M., I. Boughattas, V. Alphonse, A. Livet, S. Gıustı-Mıller, M. Bannı, et N. Bousserrhıne. 2020. « Heavy Metal Accumulation and Changes in Soil Enzymes Activities and Bacterial Functional Diversity under Long-Term Treated Wastewater Irrigation in East Central Region of Tunisia (Monastir Governorate) ». *Agricultural Water Management* 235: 106150. https://doi.org/10.1016/j.agwat.2020.106150.

Schmitt, N., A. Wanko, J. Laurent, P. Bois, P. Molle, et R. Mosé. 2015. « Constructed Wetlands Treating Stormwater from Separate Sewer Networks in a Residential Strasbourg Urban Catchment Area: Micropollutant Removal and Fate ». *Journal of Environmental Chemical Engineering* 3 (4, Part A): 2816-24. https://doi.org/10.1016/j.jece.2015.10.008.

Tedoldi, D., G. Chebbo, D. Pierlot, Y. Kovacs, et M-C. Gromaire. 2017. « Assessment of Metal and PAH Profiles in SUDS Soil Based on an Improved Experimental Procedure ». *Journal of Environmental Management* 202: 151-66. https://doi.org/10.1016/j.jenvman.2017.06.063.