

11^e Conférence internationale

LYON 2023 — L'eau dans la ville | Urban water

Organisée par

graie
POLE
EAU & TERRITOIRES

OTHU

MÉTROPOLE
GRAND LYON

nôvatech

L'eau dans la ville | Urban water

Fate of organic micropollutants in soils of stormwater management facilities at source: interactions between microbial diversity and biodegradability of micropollutants

Andréa Oudot, Elodie Bettembos, Vanessa Alphonse, Lila Boudahmane, Emilie Caupos, Mohamed Barakat, Wafa Achouak, Marie-Christine Gromaire and Nouredine Bousserhine



UNIVERSITÉ
PARIS-EST CRÉTEIL
VAL DE MARNE



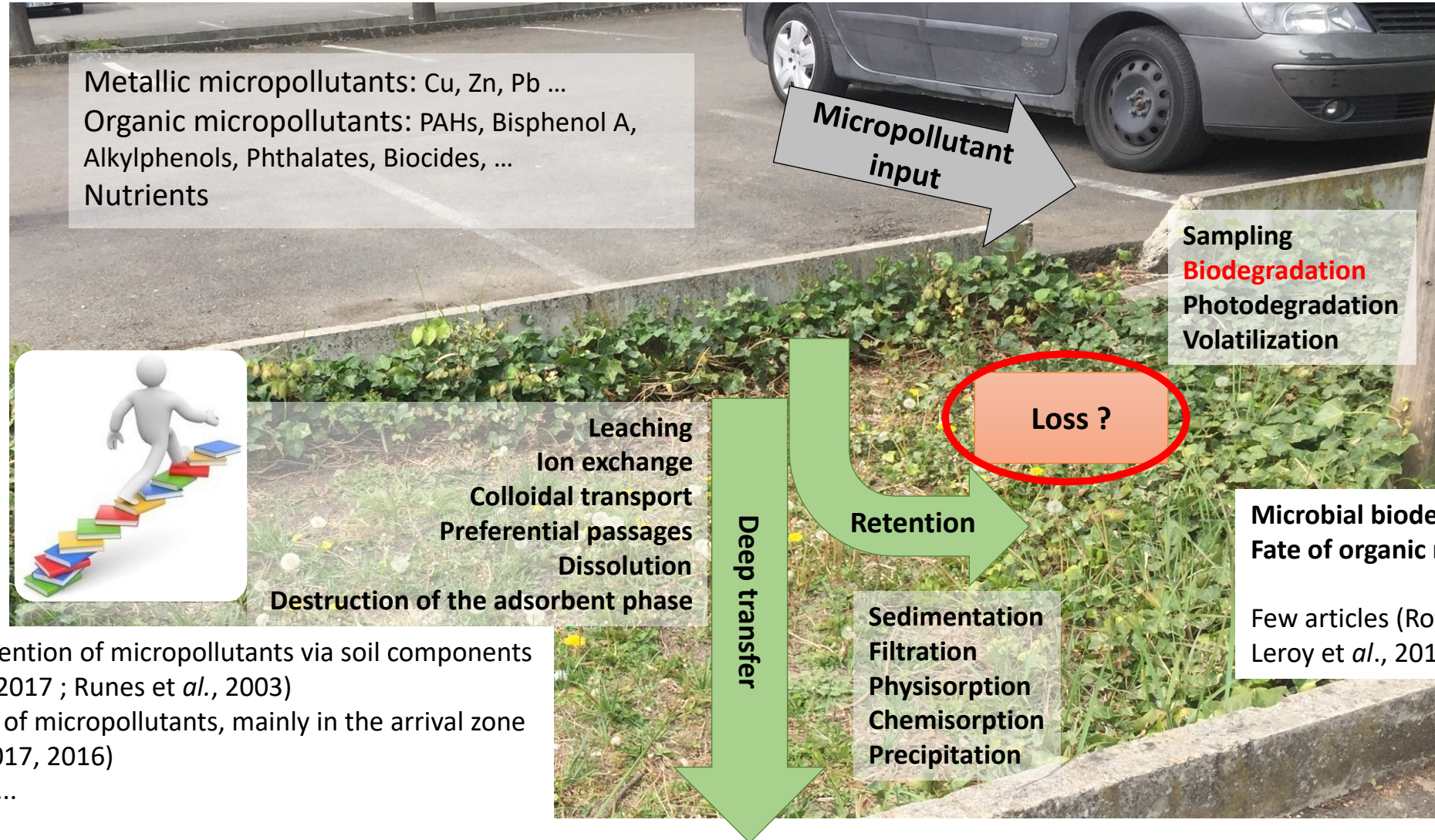
laboratoire eau environnement systemes urbains



École des Ponts
ParisTech

Stormwater management systems at source

Processes involved in infiltration structures



Microbial biodegradation?
Fate of organic micropollutants?
Few articles (Rotaru et al., 2011 et Leroy et al., 2015)

Filtration and retention of micropollutants via soil components (Flanagan et al., 2017 ; Runes et al., 2003)
Bioaccumulation of micropollutants, mainly in the arrival zone (Tedoldi et al., 2017, 2016)
And many more....

Goals

- Study microbial biodegradation of infiltration structure soils
- Testing different parameters that could influence microbial biodegradation efficiency :
 - Age of the structure
 - Vegetation
 - Soil composition
 - Heterogeneity within the same structure: upstream/downstream



3 selected sites separated into 11 soils

Selected sites and soils

Sites	Pollution	Structure type	Soil texture	Age at sampling
Dourdan	Heavy road pollution	Infiltration basin	Sandy loam	25 years
Vitry	Medium road pollution	Swale	Silt	15 years
Compans	Heavy road pollution	1 swale / 2 grass strips	Sandy loam (with filter substrate: B2 and N)/ Fine silt (B1)	5 years / 1 year

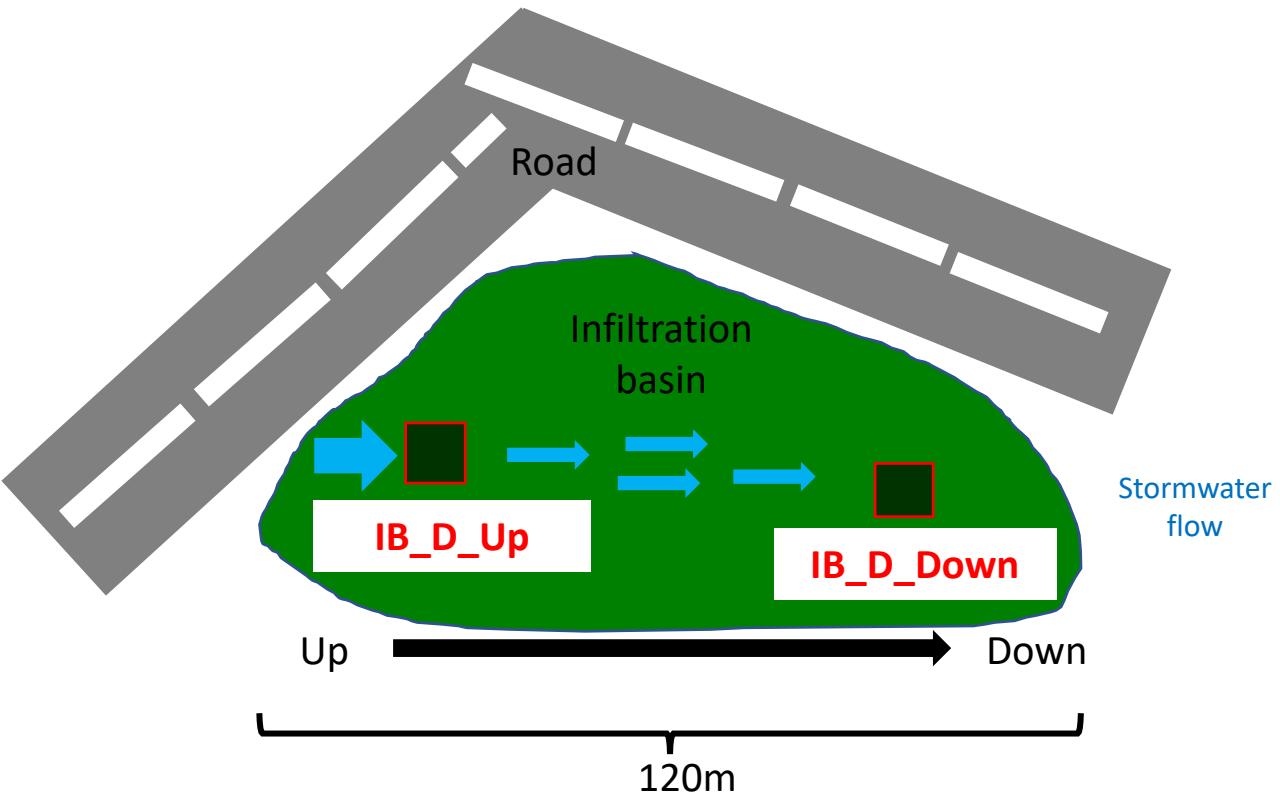
Clearance June 2020
(1 year before sampling)

Compans
Swale

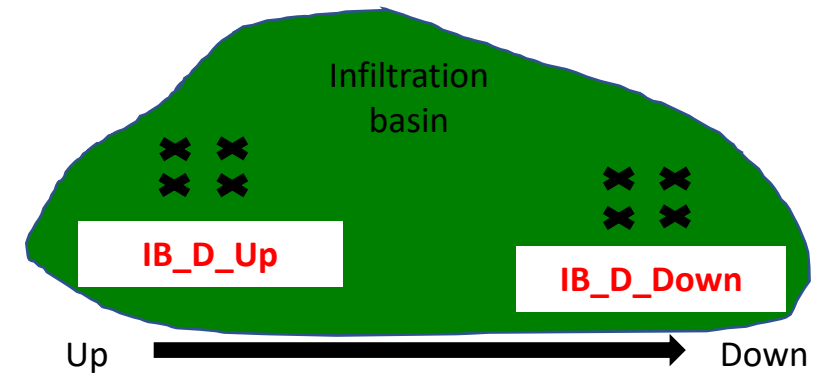
Compans
Grass strips 1/2



Site 1 : Dourdan => 2 selected soils



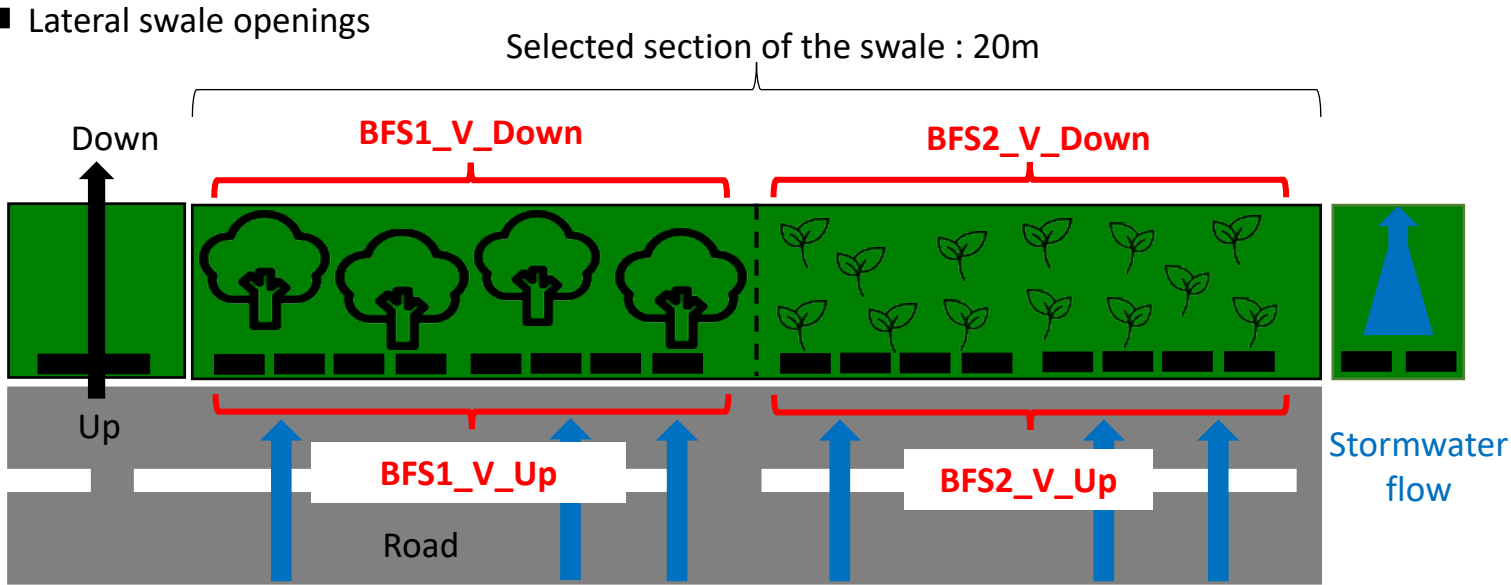
Plan of stormwater structure and flow



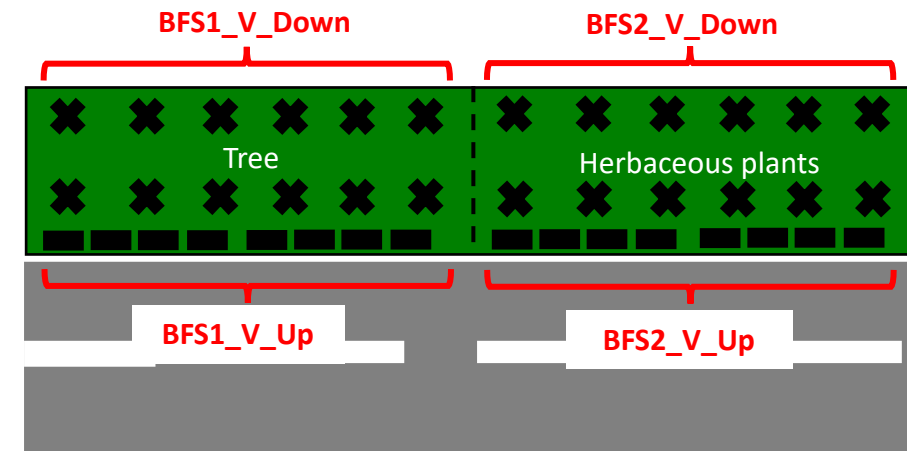
Soil sampling points:

✕ Sampling point
10cm depth

Site 2 : Vitry => 4 selected soils



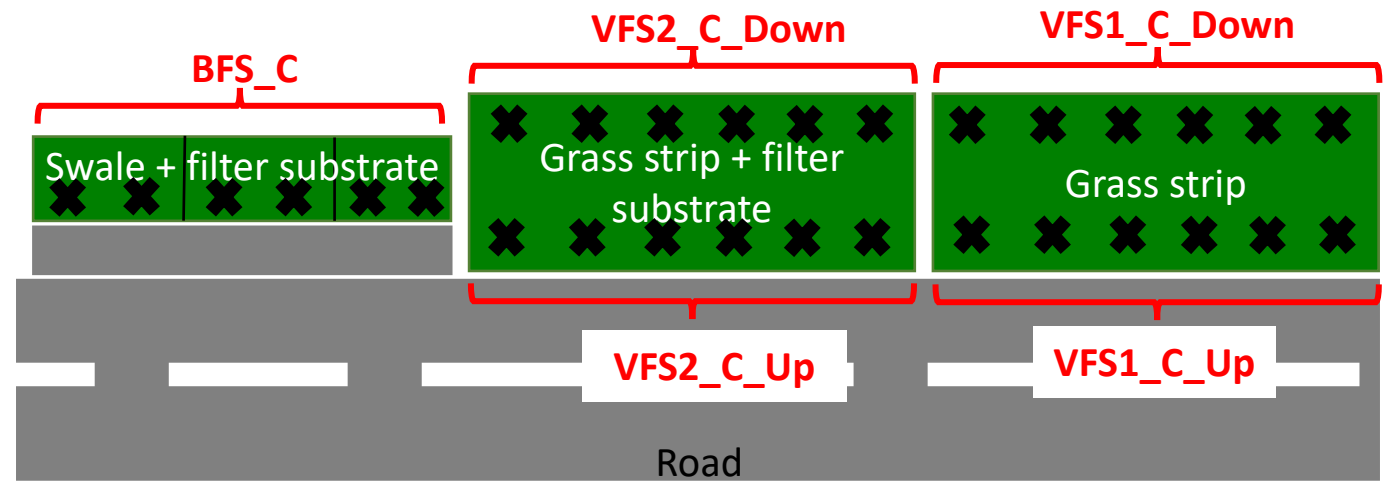
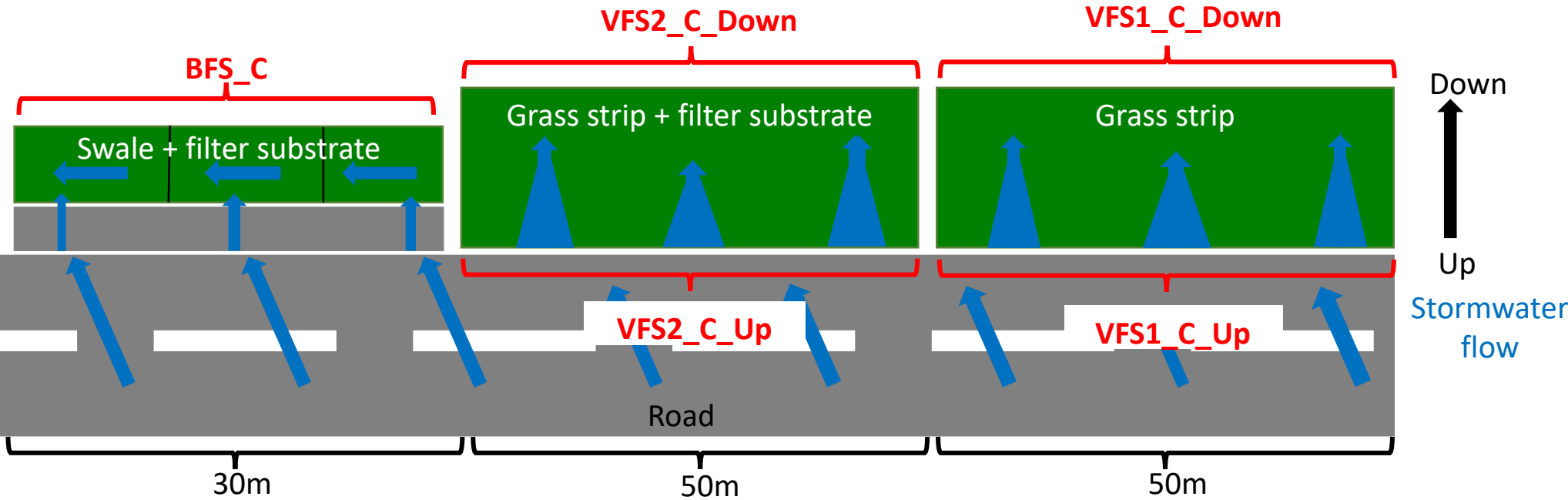
Plan of stormwater structure and flow



Soil sampling points:

- ✕ Sampling point
5cm depth

Site 3 : Compans => 5 selected soils



Soil sampling points:
 ✕ Sampling point
 10cm depth

Kinetic design

Basal salt medium (BSM)

(Peng et al, 2015)

+

Native microorganisms from
extracted soils

(Sarma et al, 2019)

+

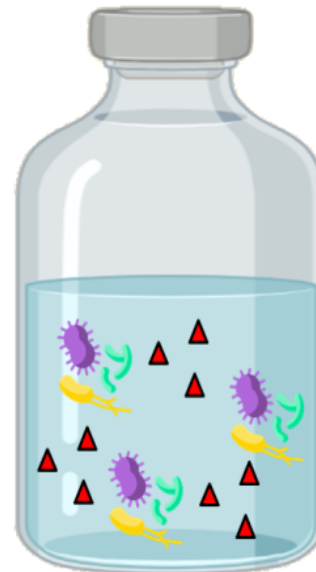
Micropollutant cocktails:

Bisphenol A: 250µg/l, ▲ ▲

Nonylphenol: 175µg/l, ▲

Octylphenol: 75µg/l

(Flanagan et al, 2018 : ratios et stage
Roux, 2019)



Mesocosms incubation:

in the dark
agitation (120rpm)
at 25°C
during 17 days.

Controls:

- biotic controls without micropollutants
- abiotic controls without microorganisms

Analysis

Physico-chemical analysis

⇒ Observation of changes in the environment and MP biodegradation

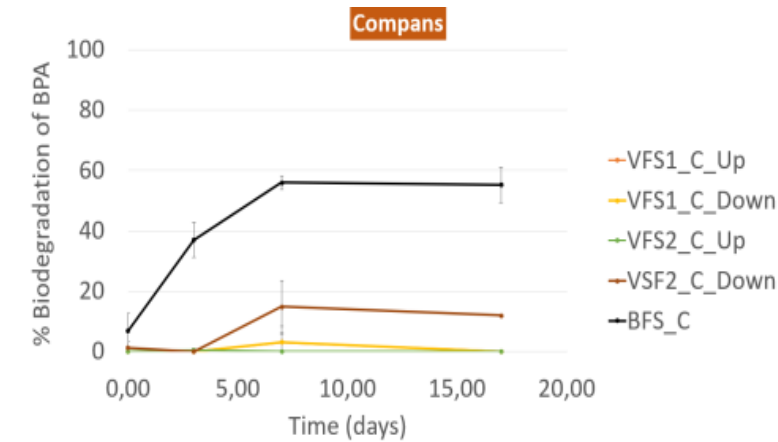
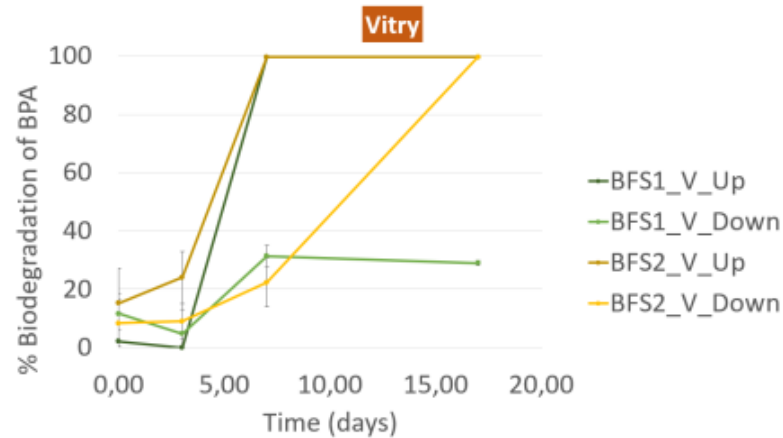
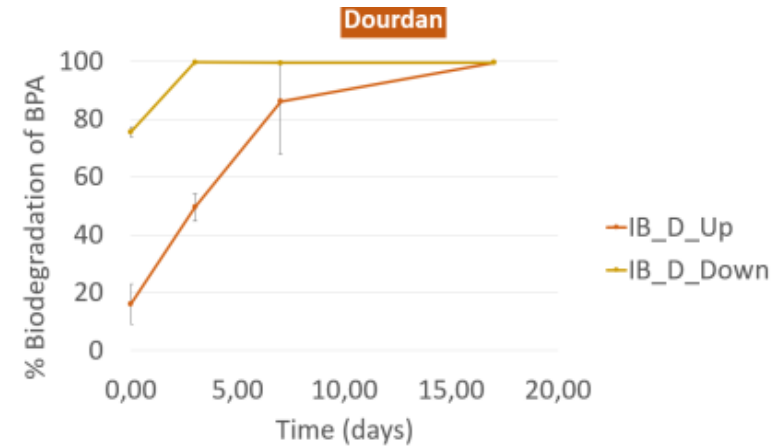
- Determination of targeted micropollutants: BPA, 4-NP and OP (biodegradation efficiency)
- pH (impact on the environment)

Biological analysis

⇒ Study of the abundance, activity and microbial diversity that can be impacted by the presence of MP

- MPN (microbial biomass: most probable number)
- CO₂ (microbial biomass)
- Biolog (microbial activity)
- Sequencing Illumina bacterial diversity : RNA 16S V3-V4

Results - BPA biodegradation



⇒ Very high biodegradation efficiency of the 2 Dourdan soils
⇒ 100% biodegradation of BPA

⇒ High biodegradation efficiency from Vitry
⇒ 100% biodegradation of BPA
⇒ Except Vitry downstream tree

⇒ Different biodegradation rates
⇒ Vitry upstream plant 100%: 7 days
⇒ Vitry downstream plant 100%: 17 days

⇒ Biodegradation efficiency of Noue: almost 60% of BPA

⇒ Other Compans soils not efficient for biodegradation

Biodegradation results at end of kinetics

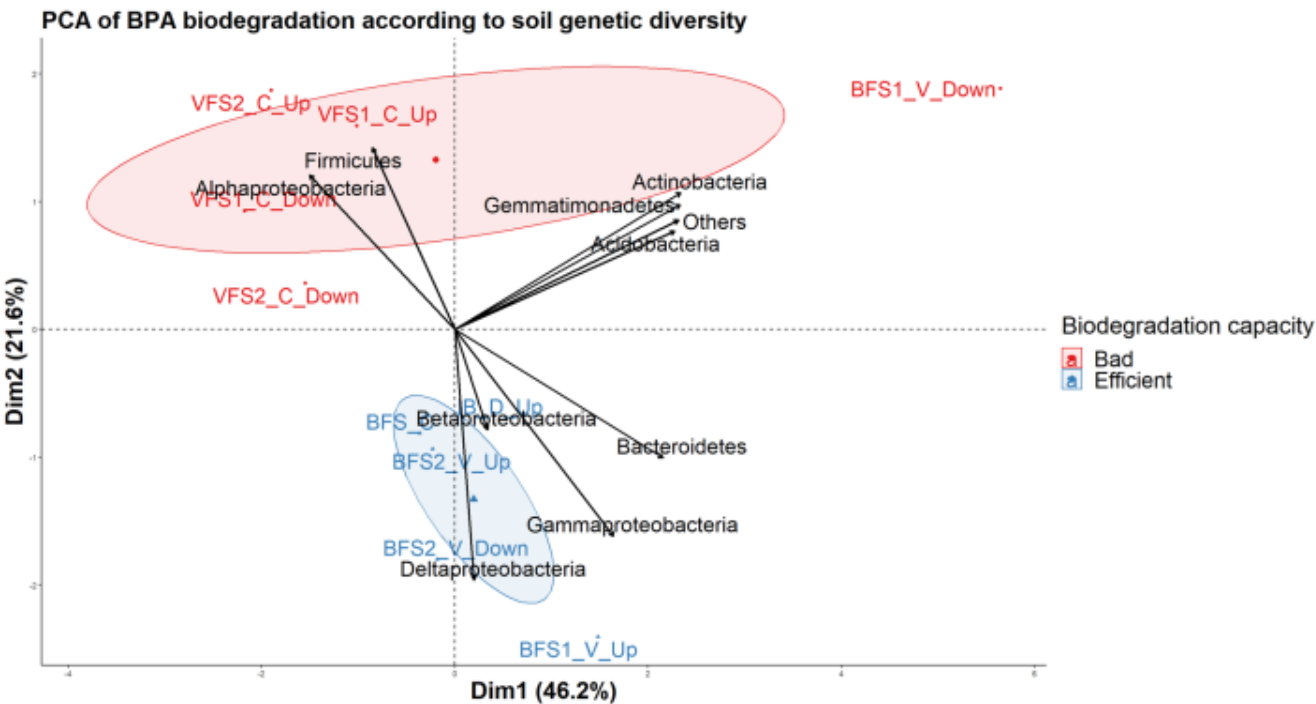
Site	Structure	Localisation	% BPA	% 4-NP	% OP
Compans	Grass strip	Up	0 +/- 0	8 +/- 1	0 +/- 0
		Down	0 +/- 0	0 +/- 0	0 +/- 0
	Grass strip + filter substrate	Up	0 +/- 0	0 +/- 0	0 +/- 0
		Down	12 +/- 0	33 +/- 0	17 +/- 5
	Swale	/	55 +/- 6	100 +/- 0	100 +/- 0
Vitry	Tree	Up	100 +/- 0	37 +/- 8	42 +/- 18
		Down	29 +/- 1	76 +/- 1	55 +/- 8
	Herbaceous plants	Up	100 +/- 0	53 +/- 3	42 +/- 7
		Down	100 +/- 0	49 +/- 1	42 +/- 3
Dourdan	Herbaceous plants	Up	100 +/- 0	94 +/- 2	95 +/- 5
		Down	100 +/- 0	100 +/- 0	100 +/- 0



Complete biodegradation

⇒ Dourdan, Vitry and Swale: soils best suited to biodegradation

Results - Relationship between BPA biodegradation efficiency and soil genetic diversity



⇒ Compans:

⇒ associated with Alphaproteobacteria and Firmicutes

⇒ BFS1_V_Down

⇒ far from the ellipse

⇒ associated with the Gemmatimonadetes, Actinobacteria, Acidobacteria and other phyla..

⇒ Dourdan, Vitry and BFS_C soils:

⇒ associated with Betaproteobacteria, Bacteroidetes, Gammaproteobacteria and Deltaproteobacteria.

⇒ Negative correlation between Firmicutes and Alphaproteobacteria with the rest of the phyla present.

⇒ Correlation of biodegradation efficiency with genetic diversity

⇒ about 60% of the information in my data is represented on this plane

Our study shows:

- ⇒ Significant differences in micropollutant biodegradation efficiencies: positive effect of hydrological load, duration of functioning and vegetation cover.
 - ⇒ biodegradation efficiency ranging from 0 to 100%.
 - ⇒ time to 100% biodegradation with the same site can vary from 7 to 17 days
- ⇒ The Dourdan and Vitry sites: the most active in terms of biodegradation:
 - ⇒ dominance of beta-proteobacteria or a greater diversity than the Compans soils.
 - ⇒ Firmicutes and Alphaproteobacteria are positively correlated with soils not biodegrading at all.
- ⇒ A more detailed genetic diversity analysis is underway to try and identify the families that are characteristic of these pollutants.
- ⇒ The kinetics were continued with the 2 most interesting soils, IB_D_Up and BFS_C, this time using columns of soil taken directly from the sites in order to be under more real-life conditions.



The results are among the first to associate diversity, microbial functionality and biodegradation potential of MOPs in structural soils. They will be useful for understanding and managing stormwater treatment facilities.

Thank you for your attention