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Interaction of micro-pollutants and micro-organism in a constructed wetland treating road runoff

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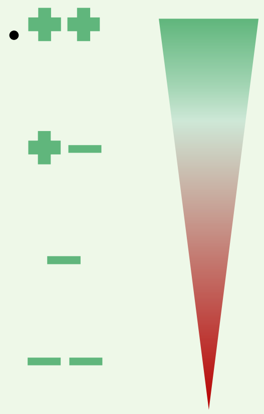
4.3b CSO treatment

Background

ICUD 2024 – Delft, session 4.3b –CSO treatment

Literature data
planted filters for runoff treatment

Reed bed filters for WWT "old" practice
Brix et al 1988



- Water treatment efficiency (TSS, N, P, metals, PAH/THC) (Walaszek et al. 2018)
- - **Dissolved /particulate** pollutants (LeFevre et al. 2015,
- - Fate of **metallic** (Dechesne et al. 2004, ….)
- - Fate of **organic** µpollutants (PAH/THC…) (Leroy et al. 2015 …)
- - Process and operation (Molle et al. 2013, Branchu et al. 2018)

- **Fate of trace elements and emerging organic µpol (AP, BPA, …)**
- *Caracterization of microbial communities and their roles*

Questions

- **LIFE-ADSORB**
- The main goal of the project is to implement and demonstrate the application of one innovative solution able to effectively reduce the pollutant loadings of rainwater runoff in a natural environment

Research (Universities)
- µpol fate
- µpol treatment processes
- Modelisation of processes
- ….

Operation (Ville de Paris)
- Management
- Treatment efficiency
- µpol flux

Us
- µpol fate accumulation and role of micro-organisms

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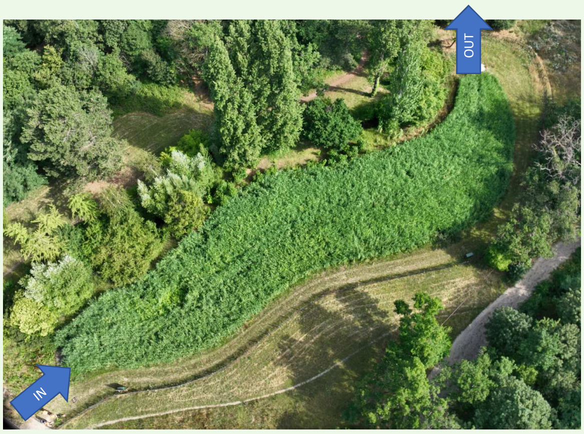
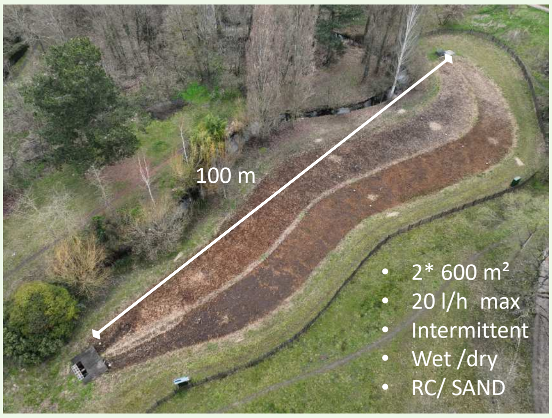
Methodology

Runoff treatment

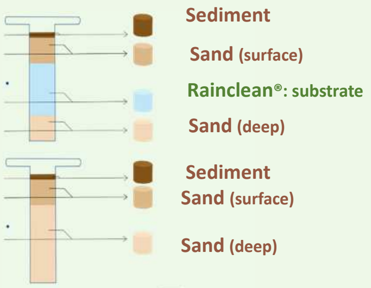
N

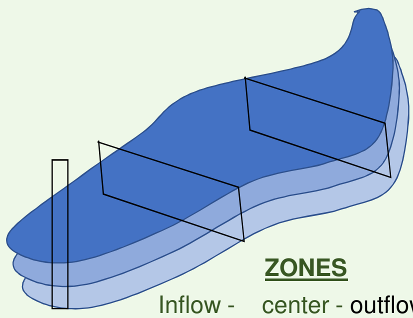
Wetland

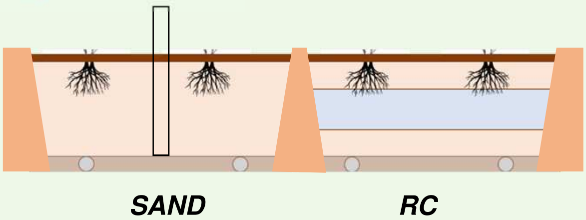




Substrate core sampling







LAYERS

- "sediment"
- 10 cm sand
- 20 cm Rainclean™
- 10 cm sand

Substrate analysis

Physico-chemistry :
pH, CEC, particle size distribution,
TOC, N, $CaCO_3$ …

Trace metals
Cd, Cr, Cu, Ni, Pb, Zn
Aqua regia + ICP-AES

Organic micropollutants
BPA , Alkylphenols (OP, NP), TC
Solvent extraction + GC-MS
or UPLC-MS-MS

Microbial communities

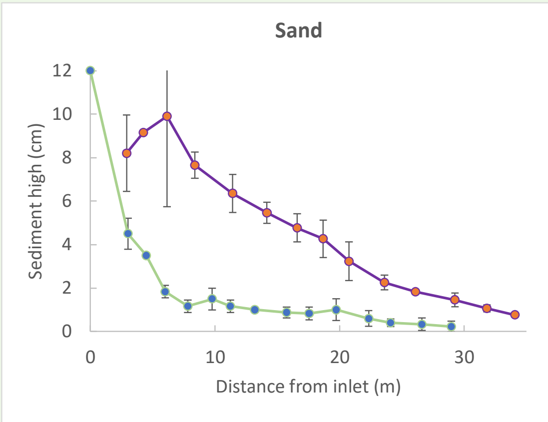
Abondance of bacteria and fungi (MNP)

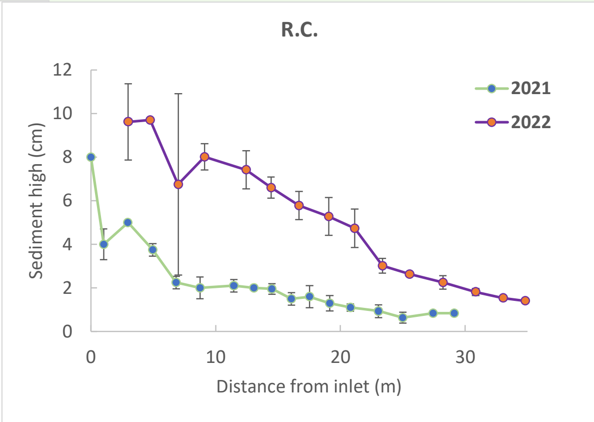
Genetic diversity (Sequencing)

Functional diversity (Enzymatic assays / EcoPlates)

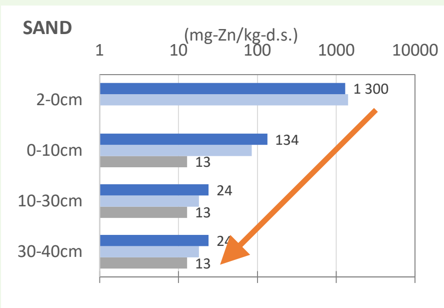
Results & discussion

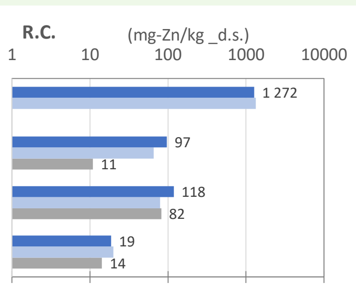
S.S. retention

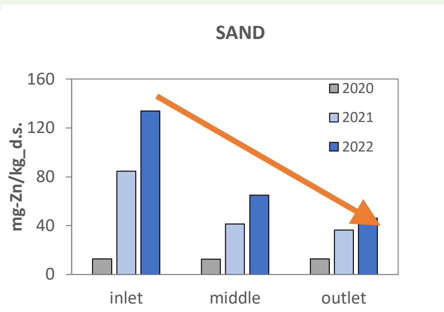




Increase of μ-pollutant concentration







(mg/kg)		Cd	Cr	Cu	Ni	Pb	Zn
SEDIMENT	T2	1,65	83,2	574	35,1	222	1300
SAND	T0	0,036	9,42	2,93	10,5	5,05	12,9
RC	T0	0,125	24	47,5	29,8	9,1	77,9

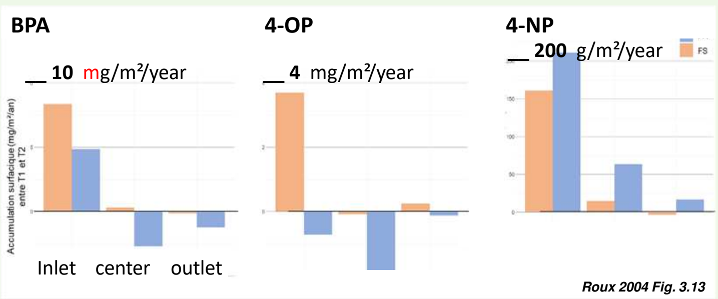
Trace metals enrichment

Eenrichiment 2 years based on g/m3

SAND	Cd	Cr	Cu	Ni	Pb	Zn
INLET	3,5	1,7	9,4	1,3	2,7	6,2
CENTER	1,5	1,4	3,1	1,7	1,1	2,5
OUTLET	1,5	1,2	2,6	1,3	1,1	2,0
Surface	3,1	1,6	9,8	1,3	2,5	6,7
Medium	1,4	1,2	2,0	2,0	0,9	1,7
Depth	1,4	1,2	2,0	1,4	0,9	1,7

RC	Cd	Cr	Cu	Ni	Pb	Zn
INLET	4,0	1,9	6,1	1,2	4,2	5,2
CENTER	1,8	1,3	2,6	1,2	1,6	2,0
OUTLET	1,6	1,7	2,9	1,6	1,6	2,1
Surface	2,4	1,0	6,4	0,9	2,1	4,4
Medium	2,1	1,8	2,5	1,7	2,0	1,9
Depth	1,0	1,2	1,5	1,1	1,0	1,2

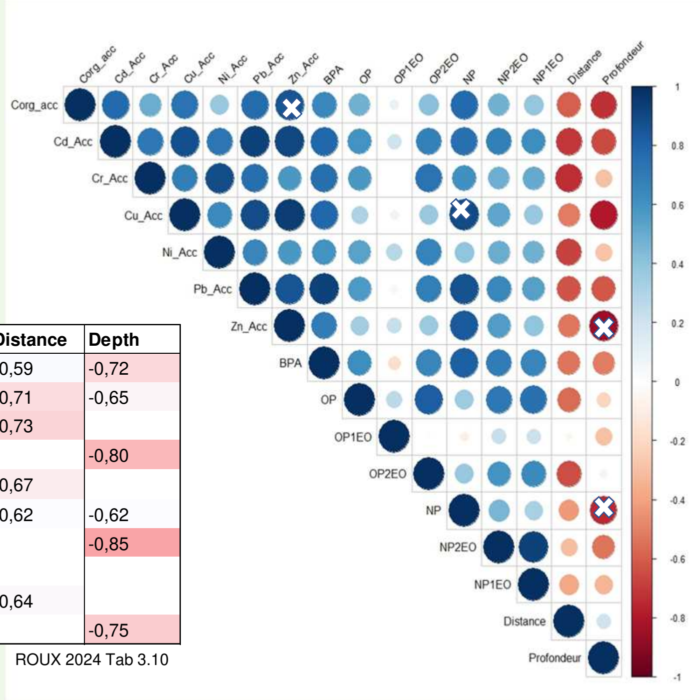
Organic µpol accumulation (g/m²/y)



SAND	BPA	4-OP	4-NP
Surface	0,8	1,1	5,7
Medium	0,1	0,4	0,1
Depth	0,1	0,4	0,1
INLET	0,5	1,4	4,0
CENTER	0,3	0,1	1,3
OUTLET	0,2	0,4	0,5

RC	BPA	4-OP	4-NP
Surface	1,5	0,4	7,2
Medium	1,1	0,1	9,5
Depth	0,3	0,3	0,6
INLET	1,1	0,3	7,8
CENTER	0,7	0,3	4,0
OUTLET	1,1	0,2	5,4

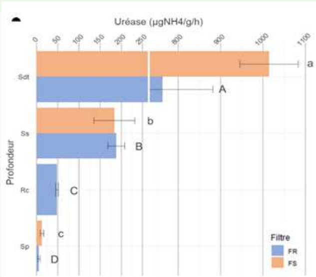
Co relations



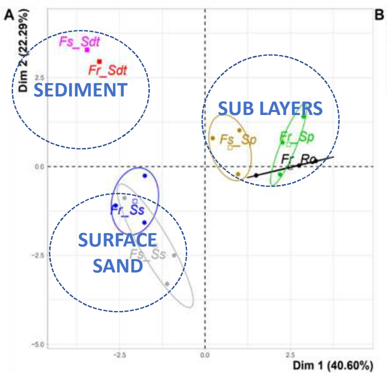
COEFF	Corg_acc	Distance	Depth
Corg		-0,59	-0,72
Cd	0,78	-0,71	-0,65
Cr		-0,73	
Cu	0,73		-0,80
Ni		-0,67	
Pb	0,77	-0,62	-0,62
Zn	0,85		-0,85
BPA	0,64		
OP2EO		-0,64	
NP	0,77		-0,75

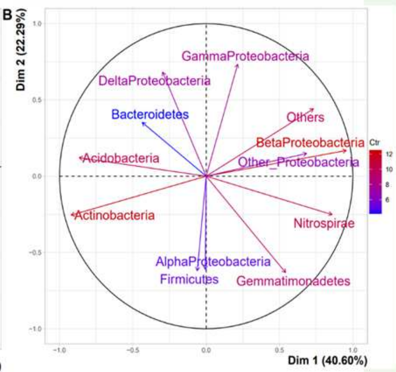
ROUX 2024 Tab 3.10

microbial activity and diversity

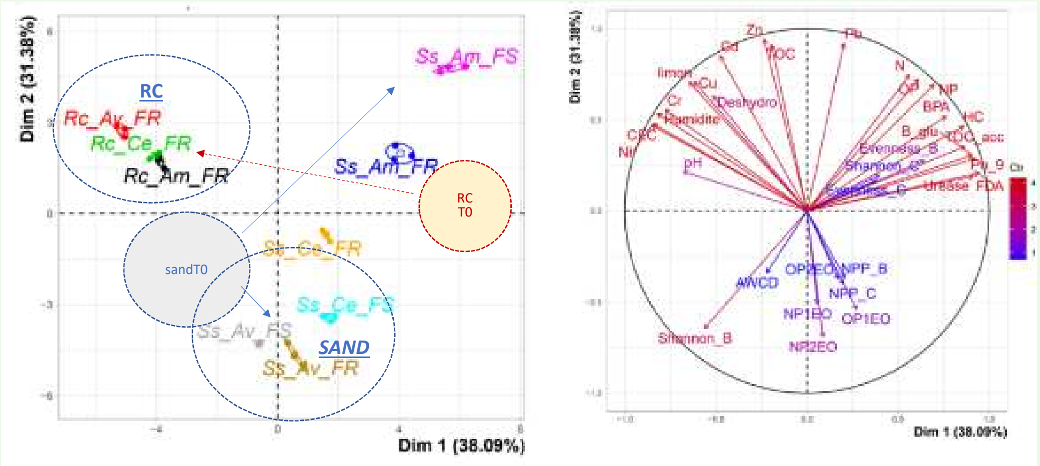


	DT50 (d)
P-sand_NP	4.35
P-RC_NP	2.55
sand_NP	15.63
RC_NP	5.11





Microbial ~~accumulation~~ evoultion



« Application »

- Wetland management

	Cd	Cr	Cu	Ni	Pb	Zn
SAND, outlet	29 - 2035	53 - 538	9 - 43	8 - 132	18 - 387	10 - 39
RC, outlet	8 - 492	4 - 32	1 - 7	1 - 13	6 - 93	3 - 12

Composé	REED wetland	Norme NF U 44-051	Ecolabel europe
Cd (mg/kg)	0,025	3	1
Cr (mg/kg)	0,41	120	100
Cu (mg/kg)	4,63	300	200
Ni (mg/kg)	0,46	60	40
Pb (mg/kg)	0,69	180	100
Zn (mg/kg)	49,2	600	300
Fluoranthène (mg/kg)	0,1	-	4
Benzo(b)fluora (mg/kg)	0,1	-	2,5
Benzo(a)pyrène (mg/kg)	0,1	-	1,5

Conclusions

Conclusions

Accumulation

Metals: mostly ccumulation and some losses = **Leaching ?**

Organic MPs: losses exept NP in trance zone 1 = **Biodegradation ?**

Substrate

Sediment: **1% volume 35-45% contribution**

Rainclean: retention capacities not (yet) demonstrated

Mass balance

Sand > R.C. for Metals ; opposite for Organic µpol

➔ Water data needed

µ-pollutant fate

The reedbed filter showed a pollution distribution according to its hydraulic functioning, a horizontal and vertical pollutant pattern according to flooding and infiltration processes. The main fraction of the pollutant is today retained in the first 40 % of the filter. Some mobile micro pollutants like Ni and Cr were better retained in the outlet zone by a specific adsorbing layer. Among the organic micro pollutants studied BPA and OP did not accumulate, but NP did. Globally the Rainclean® containg filter did slightly better than the sand filter. The bacteria followed the suspended solid deposition pattern, enriching the original substrate. First indications appeared linking specific pollutant and bacterial phyla.


Pascale
Julia
Philippe
Marie-
Christine
Noureddine
Thank you for your attention