University of Applied Sciences and Arts Northwestern Switzerland
School of Life Sciences

µGAC STEP Delémont

Analyse des grosstechnischen Prozesses

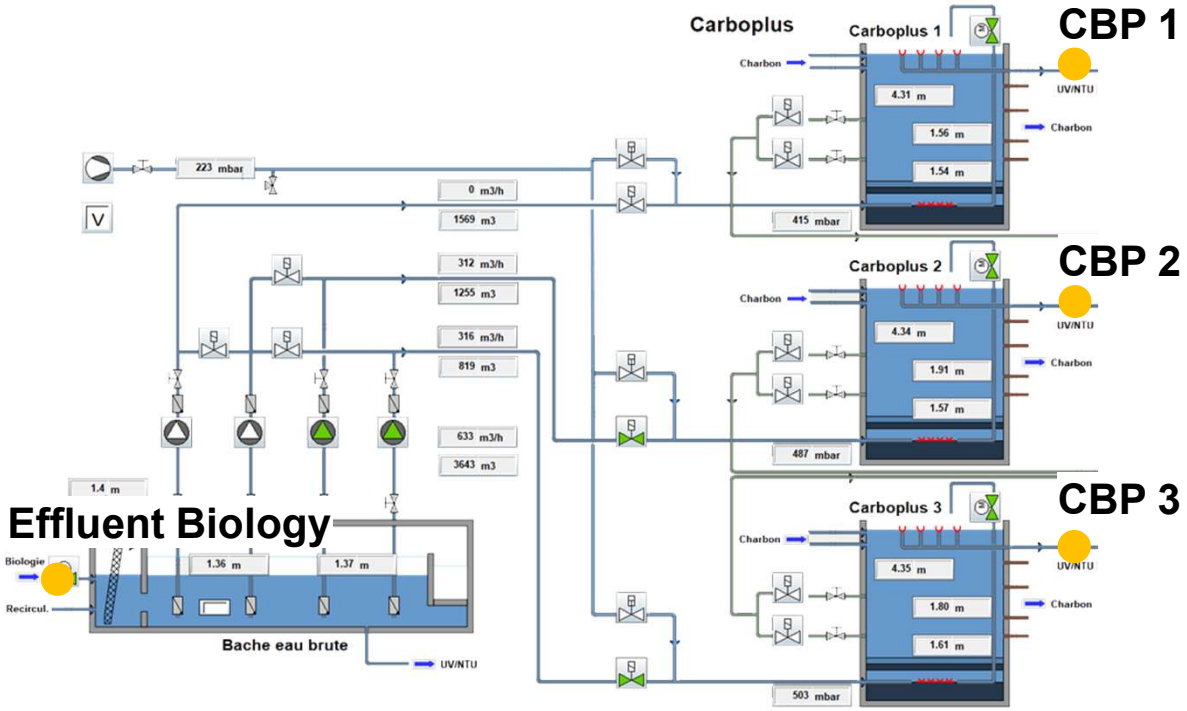
Luca Loreggian, Michael Thomann

ERFA Aktivkohle, ARA Glarnerland 4. Juni 2024

Research questions

WP	Focus	Questions
1	**Loss of µGAC**	• What is the GAC retention at different conditions? • Can a pre-washing be helpful to reduce loss of AC? • Is an additional filter needed to reduce AC loss in the effluent?
2	**µGAC consumption**	• What is the minimium dose needed for 80% elimination? • What is the optimal bed height? • How much carbon within a reactor and how long ist residence time?
3	**Rain events**	• How does the system react when the velocity in the system increases? • Which measures can be taken to reduce the matrix effect and improce the hydraulic of the system?

Sampling strategy and monitoring of Carboplus µGAC



Sampling point

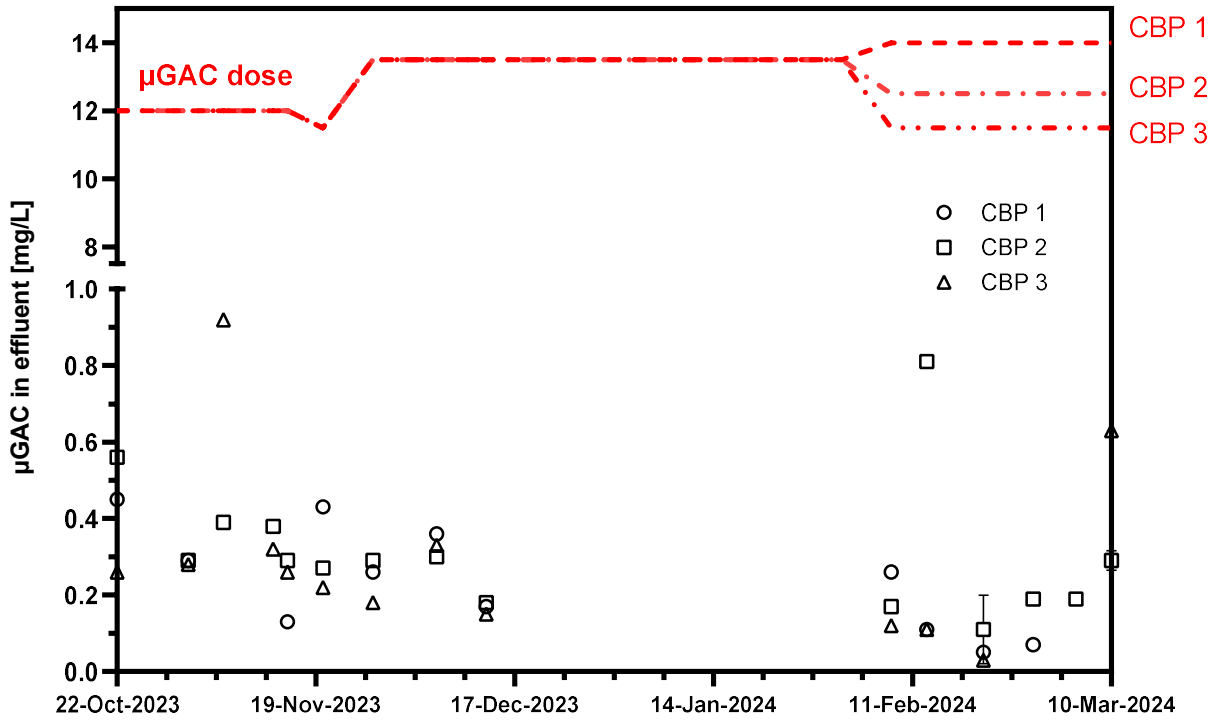
Sampling strategy

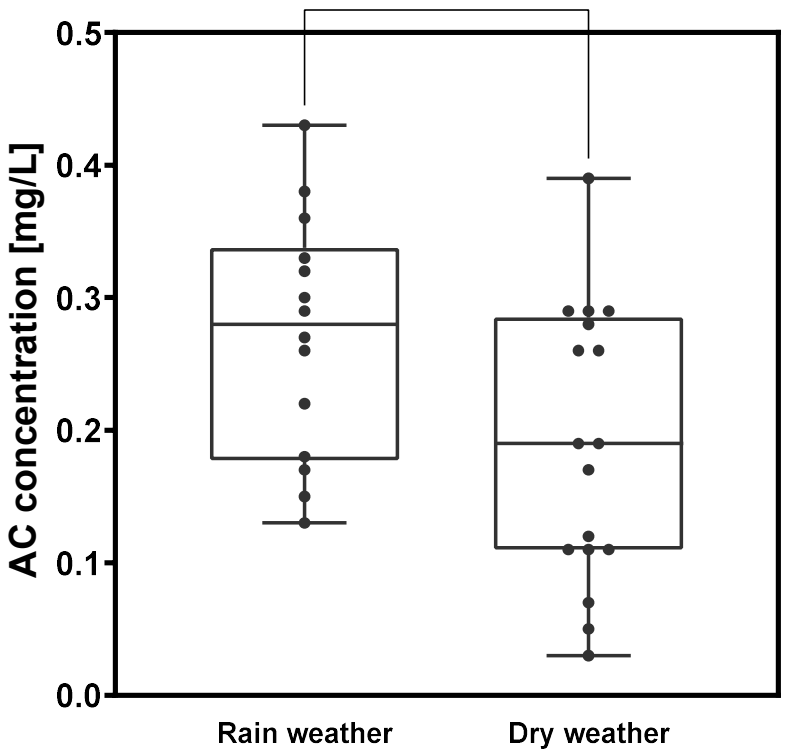
- Effluent biology, effluents of Carboplus 1, 2, 3
- 48 hours composite sample
- Weekly sample for dry weather
- Additional sample for rain events

Analytics

- 12 Micropollutants conc.
- Activated carbon loss
- TSS, Turbidity
- UV, DOC

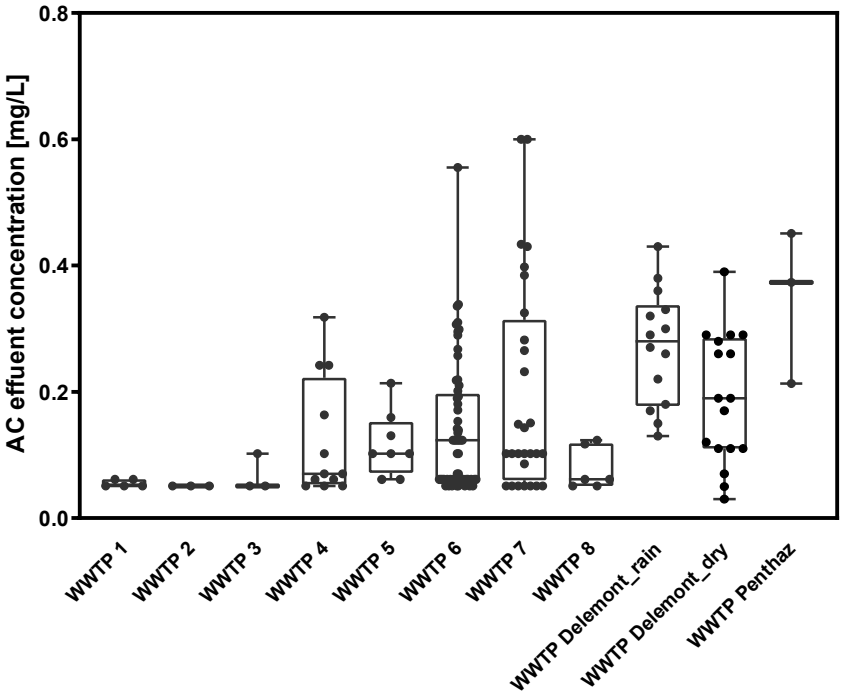
µGAC dosage and effluent AC concentrations (MIPA²C)

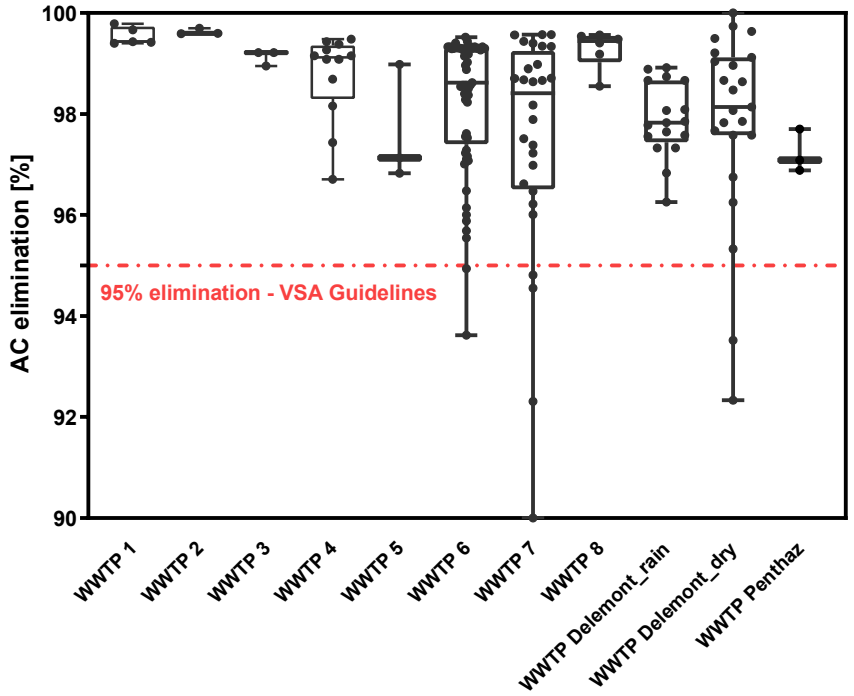




- Average concentration in the effluent 0.28 + 0.18 mg/L
- 0.31 mg/L at rain weather and 0.22 mg/L at dry weather

µGAC and PAC – effluent AC concentrations (MIPA²C)





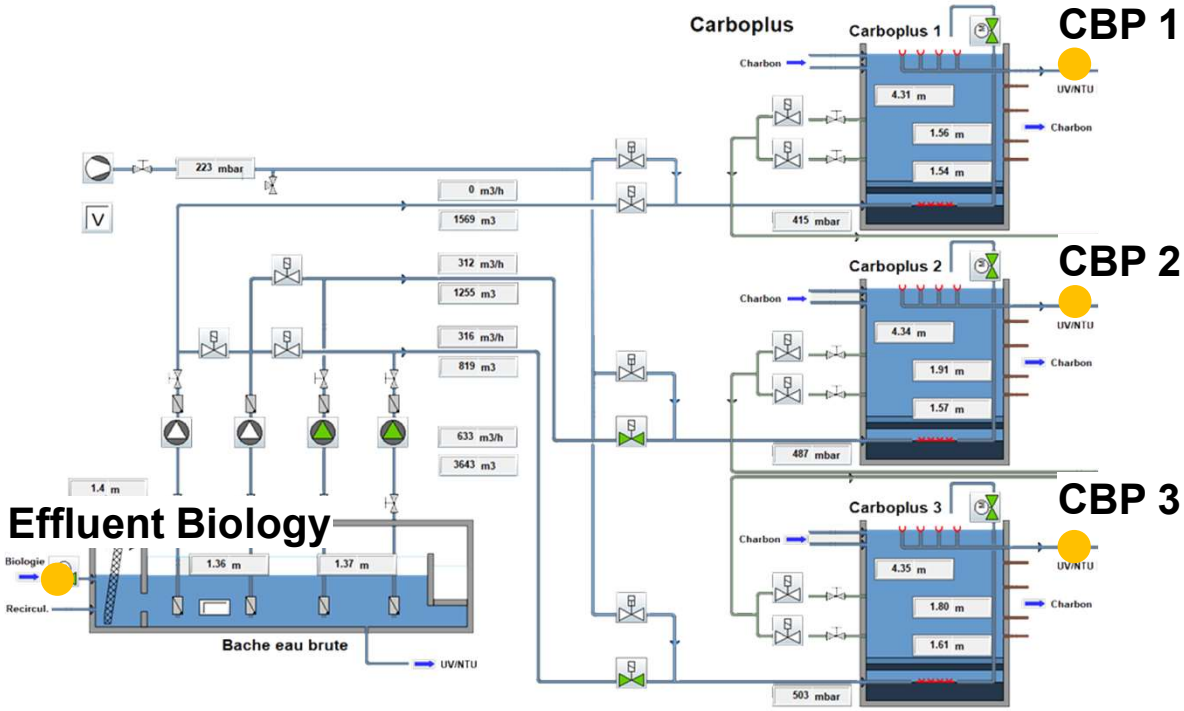
- AC in the effluent is higher when µGAC is used (< 0.2 mg/L) than PAC and a filter
- µGAC retention in moving bed is lower than PAC, but higher then 95% (VSA guideline)

WP1 – loss of carbon

Summary:

- Activated carbon retention is generally higher than 95%
- Three cases only of AC concentration above 95% threshold (7% of sampling campaign)
- µGAC loss in the effluent is higher than in other AC processes with filtration (i.e. PAC/Sand filter)
- Average loss of µGAC during rain event is higher than at dry weather, but difference is not statistically significant

WP2 - µGAC consumption



● Sampling point

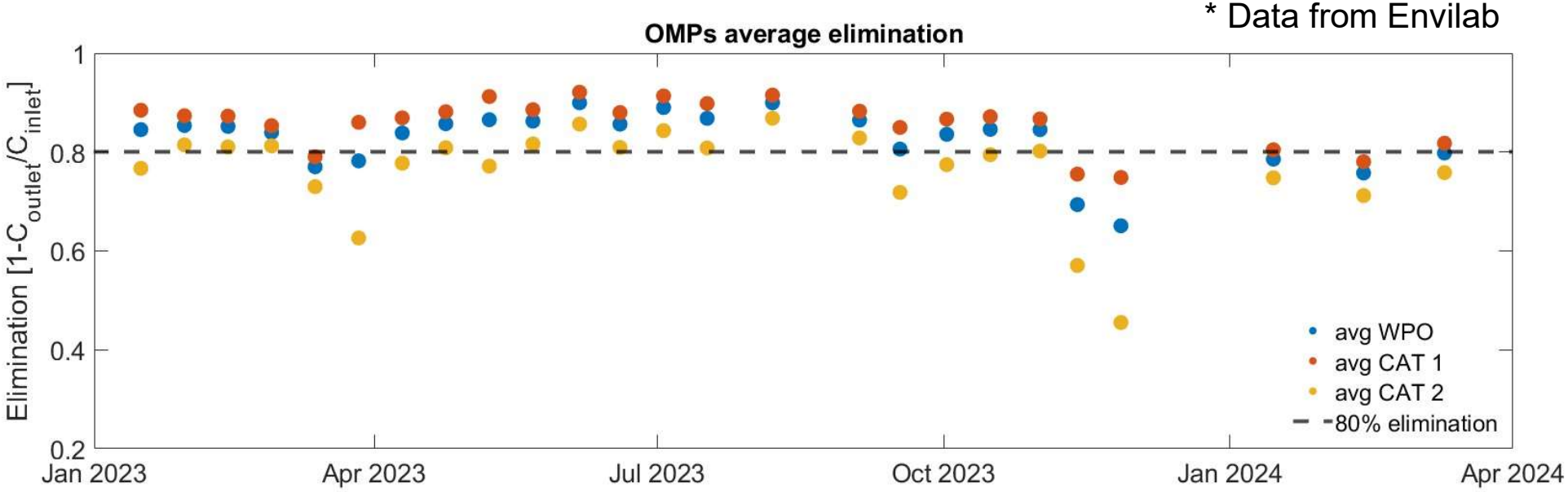
Sampling strategy

- Effluent biology, effluents of Carboplus 1, 2, 3
- 48 hours composite sample
- Weekly sample for dry weather
- Additional sample for rain events

- CBP 1 14 g/m^3
- CBP 2 12.5 g/m^3
- CBP 3 11.5 g/m^3
- From February to March…

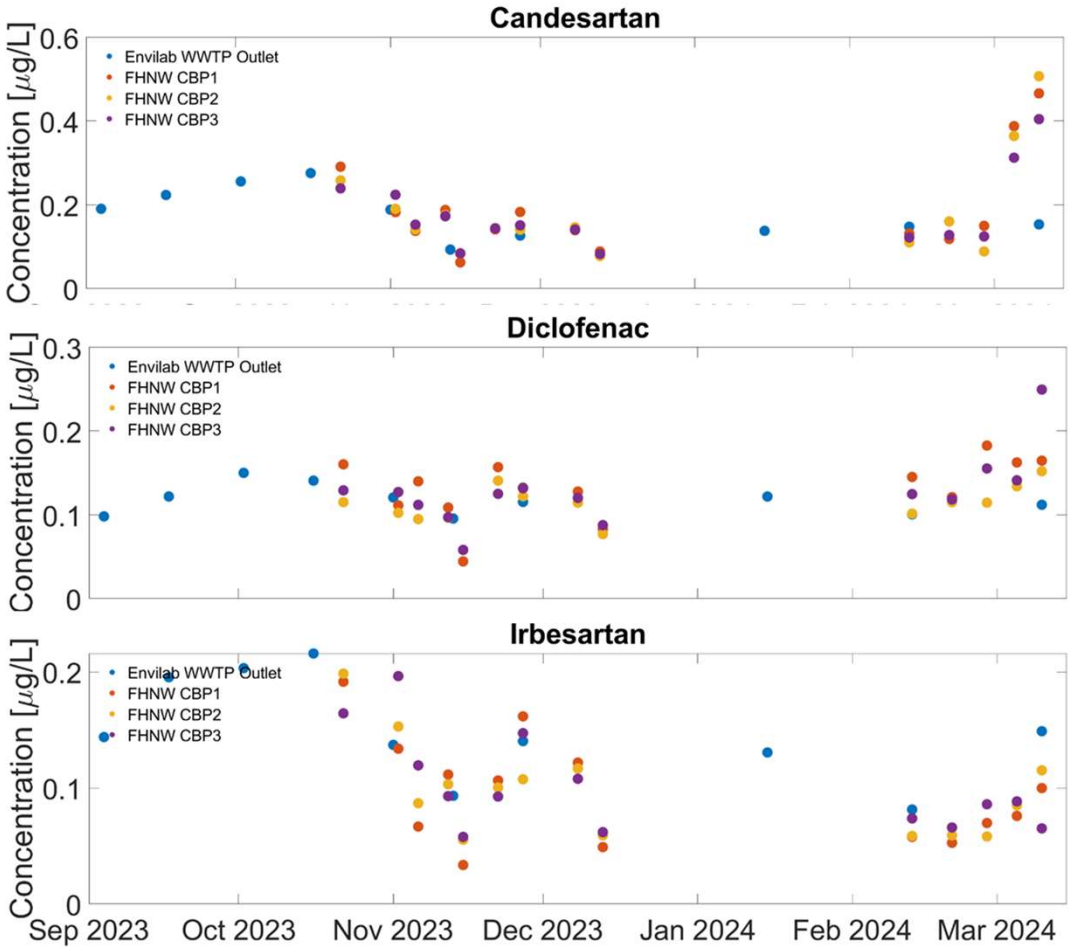
Organic micropollutants elimination (OMPs)

* Data from Envilab



- µGAC in moving bed appears as a robust process that ensures constant OMPs elimination, Regularly > 80%.

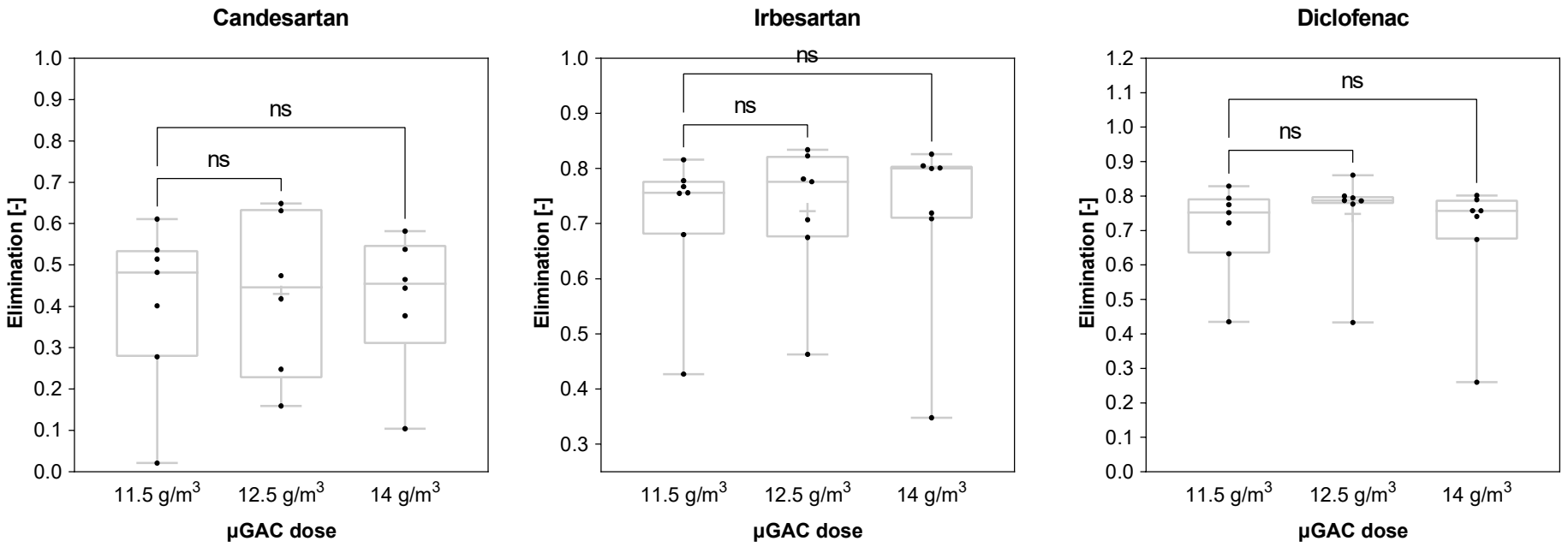
OMPs effluent concentrations (Envilab & FHNW)



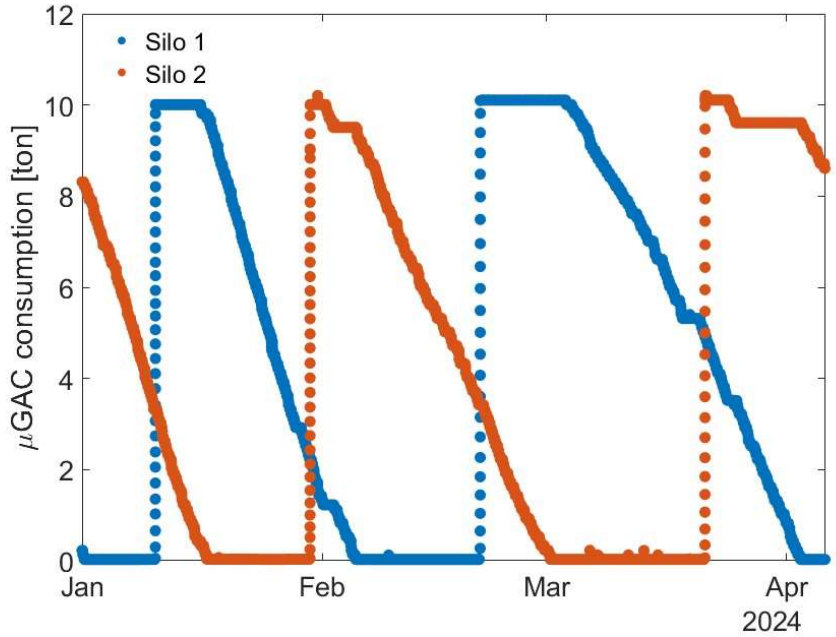
- Comparison of Envilab and FHNW analytics for validation of results
- CAT1 substances (Amisulpride, Carbamazepine, Citalopram, Clarithromycin, Metoprolol) are often too diluted for comparison
- These molecules “score” very high elimination when LOQ is used for delta calculation.

$$\Delta OMPs = 1 - \frac{Concentration_{\,eff.}}{Concentration_{inf.}}$$

Response of OMPs elimination to AC dose



µGAC consumption and reactor size



- ~40 tons µGAC
- 109 days of operation
- 0.36 ton/day

		Delemont	Penthaz
Number of reactors	-	3	2
W	m	6.5	3.5
D	m	6.6	3.5
Surface of one reactor	m^2	42.9	12.3
Bed height at rest	m	1.75	1.5
Filter volume at rest in one reactor	m^3	75.1	18.4
Total µGAC consumption	kg/day	333	45
Mass of carbon in one reactor	t	33	8.2
Bulk density of µGAC	t/m^3	0.44	0.44
Average age of µGAC	day	**298**	**364**

Insufficient time to see differences

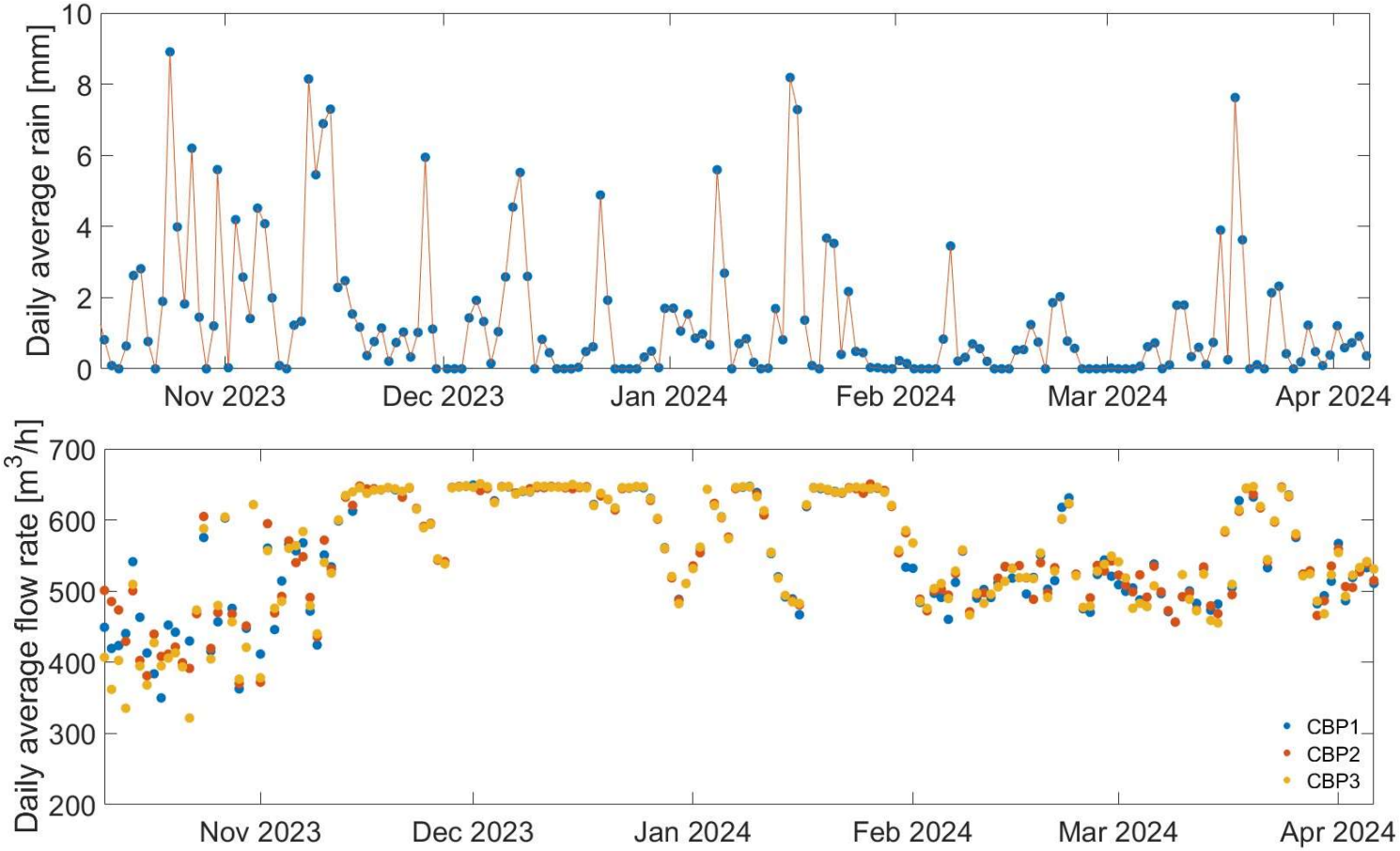
WP2 - µGAC consumption

Summary

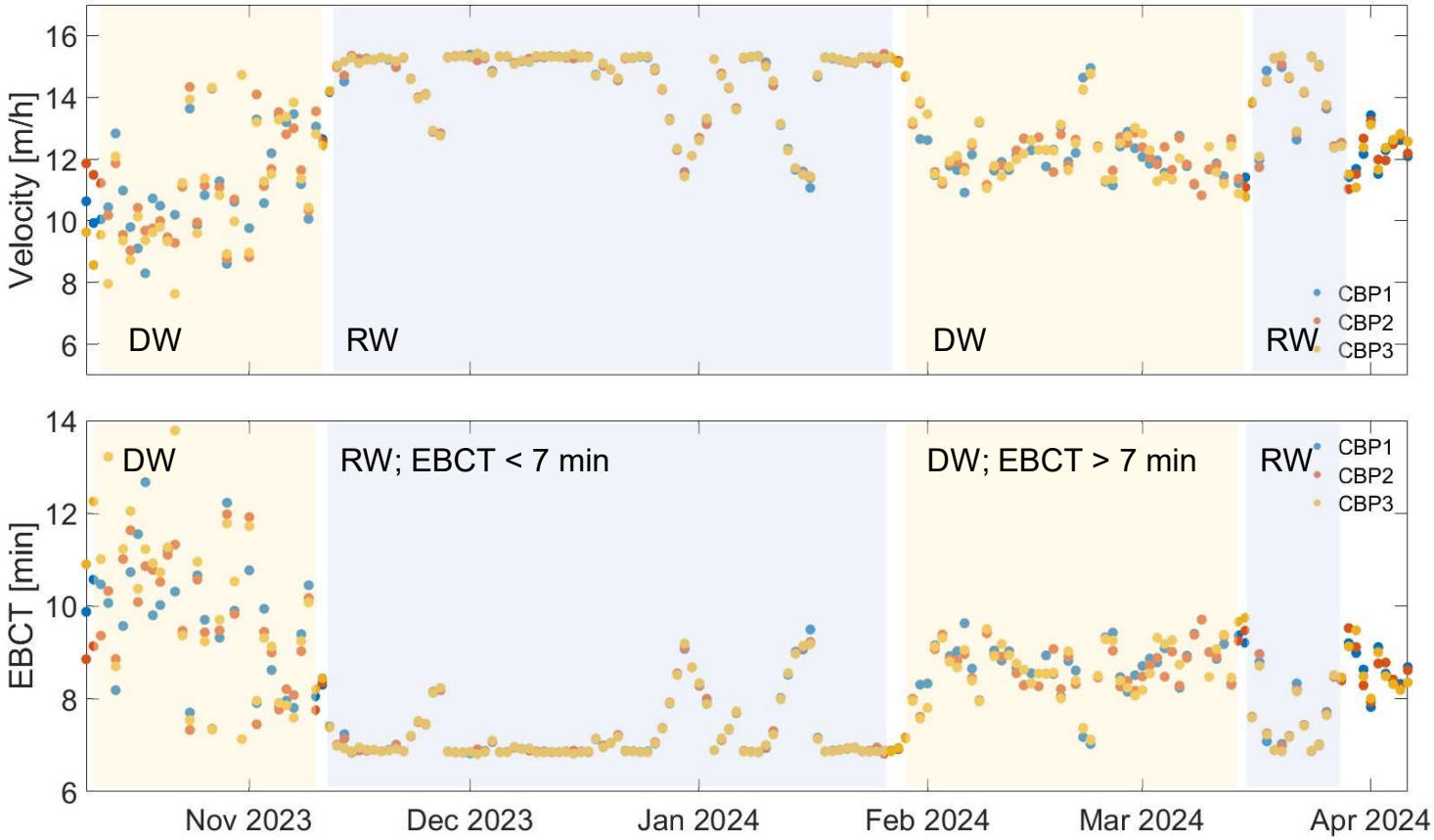
- Dosage of µGAC does not appear to significantly affect OMPs elimination over the period of investigation
- Longer sampling campaign may show differences between the systems
- The long age of µGAC (> 298 days) is assumed to slow down responsiveness of the process

- Hence, it is hypothesized that sudden changes of OMPs elimination are due to other factors such as dilution, hydraulic residence time, temperature…

WP3 – OMPs elimination during rain events



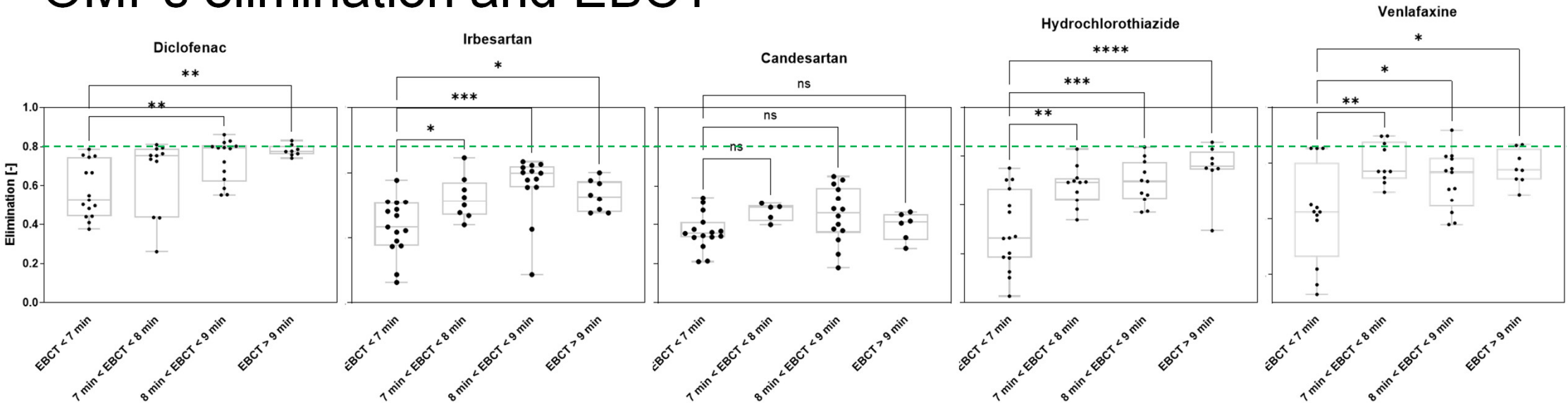
WP3 – OMPs elimination during rain events



DW: Dry weather conditions

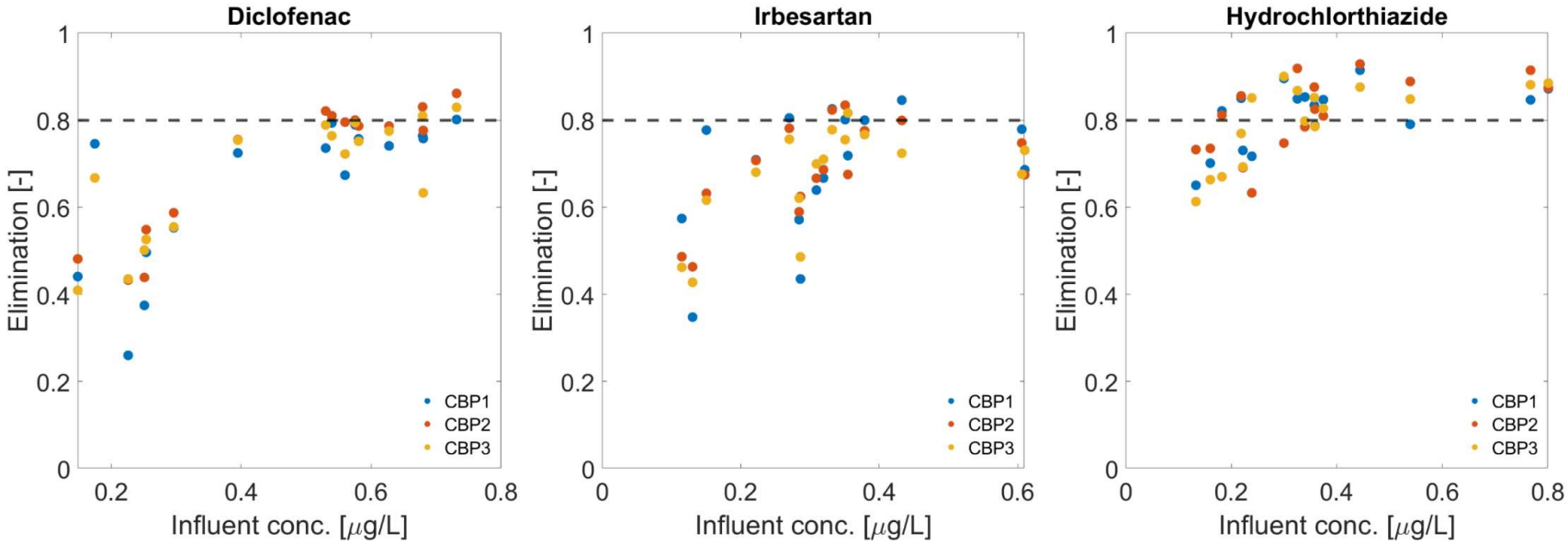
RW: Rain weather conditions

OMPs elimination and EBCT



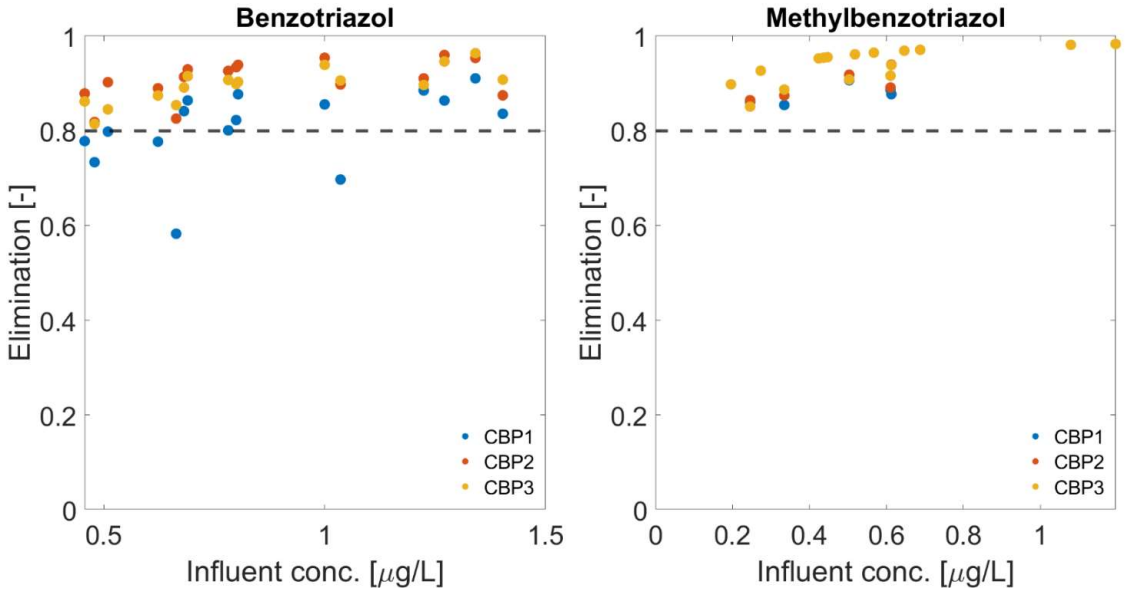
- Elimination of Diclofenac, Irbesartan, Hydrochlorthiazide and Venlafaxine decreases at short EBCT
- Candesartan does not show significant differences → Is EBCT = 9 minutes too short for this molecule?

OMPs elimination at low concentrations



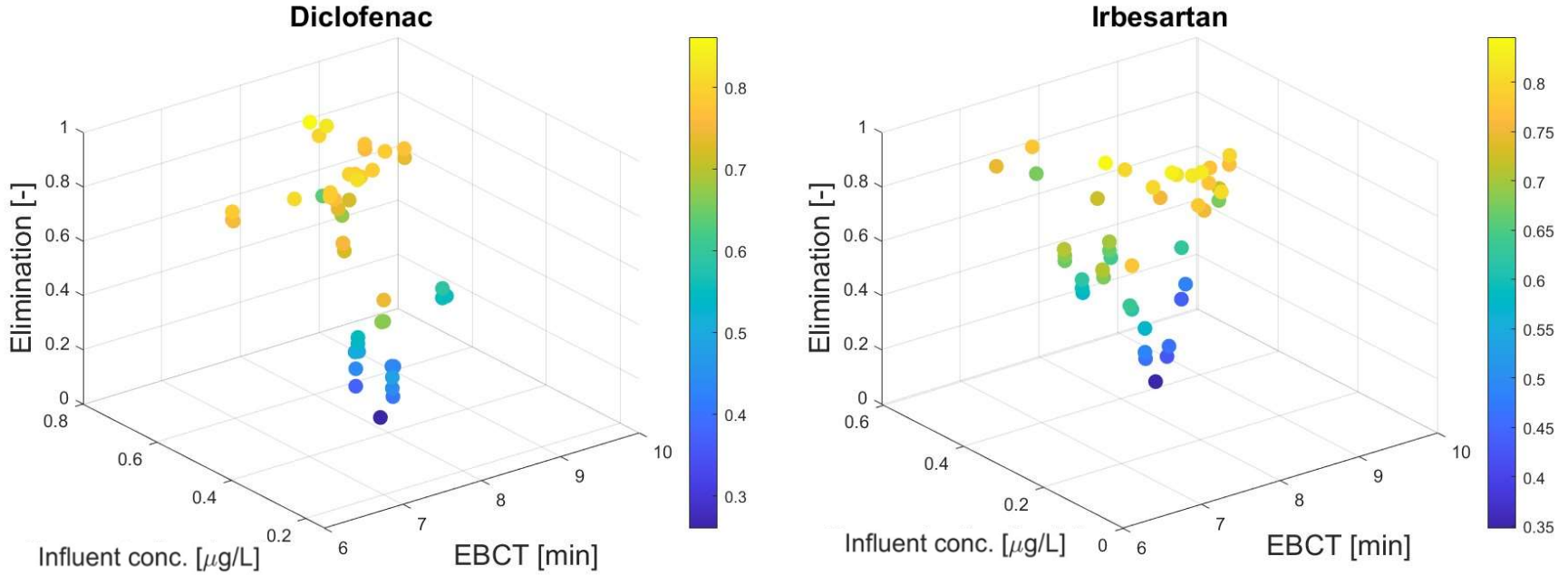
- Less adsorbing substances (e.g. DIC, IRB) are less eliminated at low influent concentrations

OMPs elimination at low concentrations



- Well adsorbing substances (e.g. BTA, MeBTA) are not affected as strongly
- Their elimination is likely not to change at rain events

OMPs elimination over EBCT and concentration



- High elimination at long EBCT (> 7 min) and higher concentration (i.e. dry weather conditions)
- Low elimination at short EBCT (< 7 min) and diluted water (i.e. rain weather conditions)

WP3 – Rain events and OMPs elimination

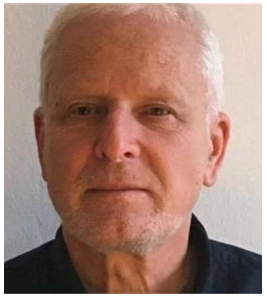
Summary

- During rain events velocity increases and EBCT decreases to less than 7 minutes, thus reduction of the available time for adsorption
- Additionally, concentrations of OMPs are diluted. Low concentration also negatively impact adsorption of some molecules
- At these conditions, the less adsorbable compounds are badly eliminated
- On the contrary, well adsorbing substances continue to be well eliminated (Δ > 80 %).

Conclusions

- µGAC retention complies with current VSA Guidelines (> 95%)
- Exceptions are found during rain events → A deeper look at the rain events and bed behaviour is due
- Category 1 molecules (indicator substances) are well eliminated at both dry and rain weather conditions
- Challenging compounds are negatively affected by rain event conditions (i.e. short EBCT and dilution)
- Due to inertia of the system, µGAC dosing does affect OMP elimination at longer time scale
- Contrary to PAC, µGAC dosing cannot be adjusted for lack of adsorption at challenging conditions

Thank you for your attention.



Benjiamin Gigax, FHNW

Nora Corvini, FHNW

Michael Pulfer, FHNW

Pierre-Michel Seuret, SEDE

Nathan Burkhalter, SEDE

Max Schachtler, Step-ara.ch

Marc Böhler, EAWAG

Caroline Bailat, SEDE

Thanks everybody for your help!

University of Applied Sciences and Arts Northwestern Switzerland
School of Life Sciences

µGAC STEP Delémont

Analyse des grosstechnischen Prozesses

Luca Loreggian, Michael Thomann

ERFA Aktivkohle, ARA Glarnerland 4. Juni 2024