Renewable granular active carbon for removal of organic micropollutants in urban wastewater

Luca Loreggian

Fachhochschule Nordwestschweiz

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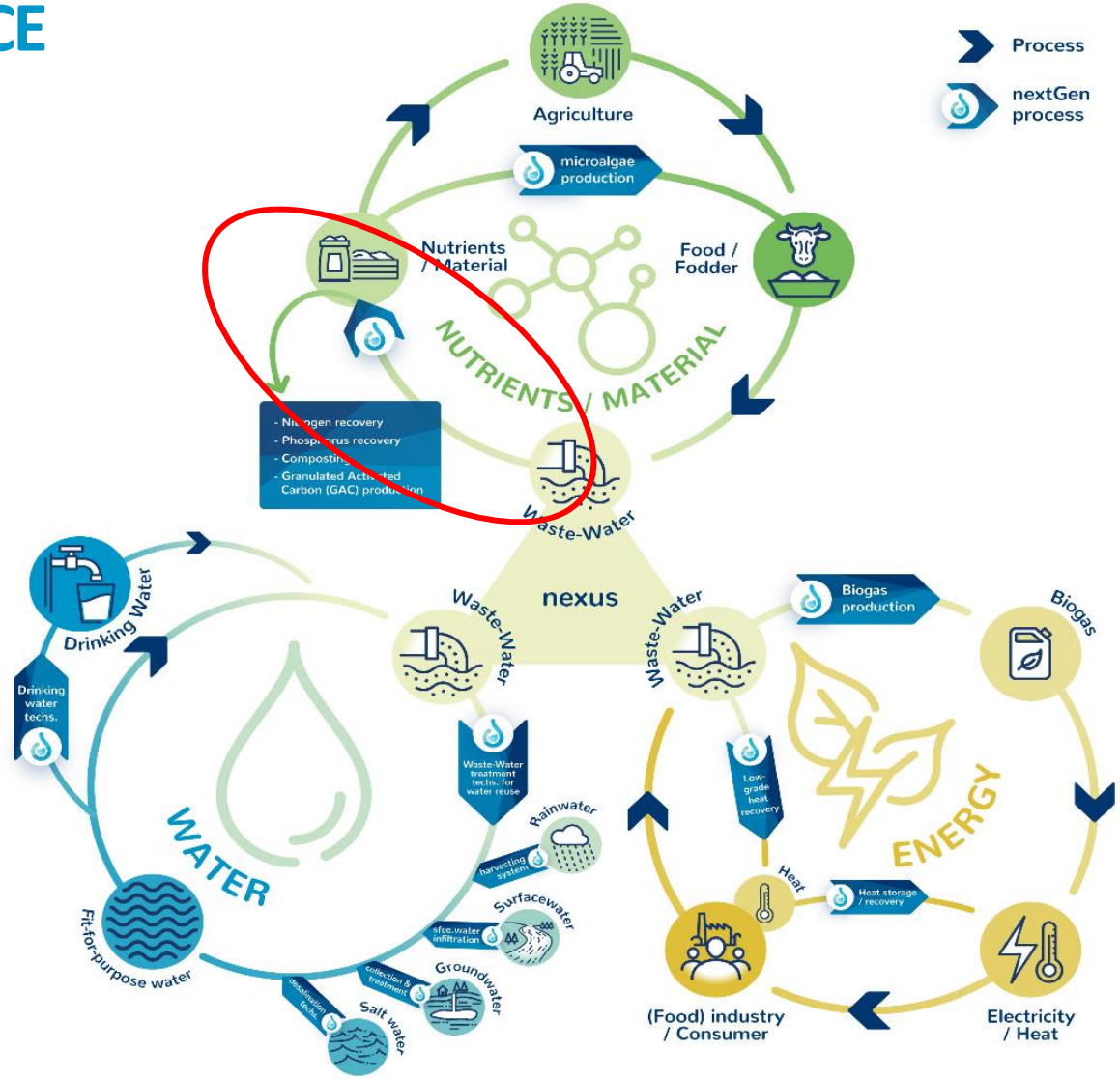
Objectives of the NextGen solutions

Positioning of demo case within the CE

Materials

- Recovery of phosphorus in sludge for reuse as P-fertilizer
- Nitrogen stripping via membrane contactor
- Production of granular activated carbon using local biomass and sludge



Altenrhein

Switzerland

Circular solutions for

Materials

Relevant data

WWTP: 100,000 PE; 300,000 PE (sludge treatment)

Lead partner: Fachhochschule Nordwestschweiz

Other partners: ABWASSERVERBAND ALTENRHEIN

Relevant sectors **Water treatment**

Altenrhein – General description of the site

WWTP: 100,000 PE; 300,000 PE (sludge treatment)

Primary treatment:
bar screens, sand trap, primary clarifier

Secondary treatment:
nitrification, denitrification, enhanced biological phosphorus removal, secondary clarifier

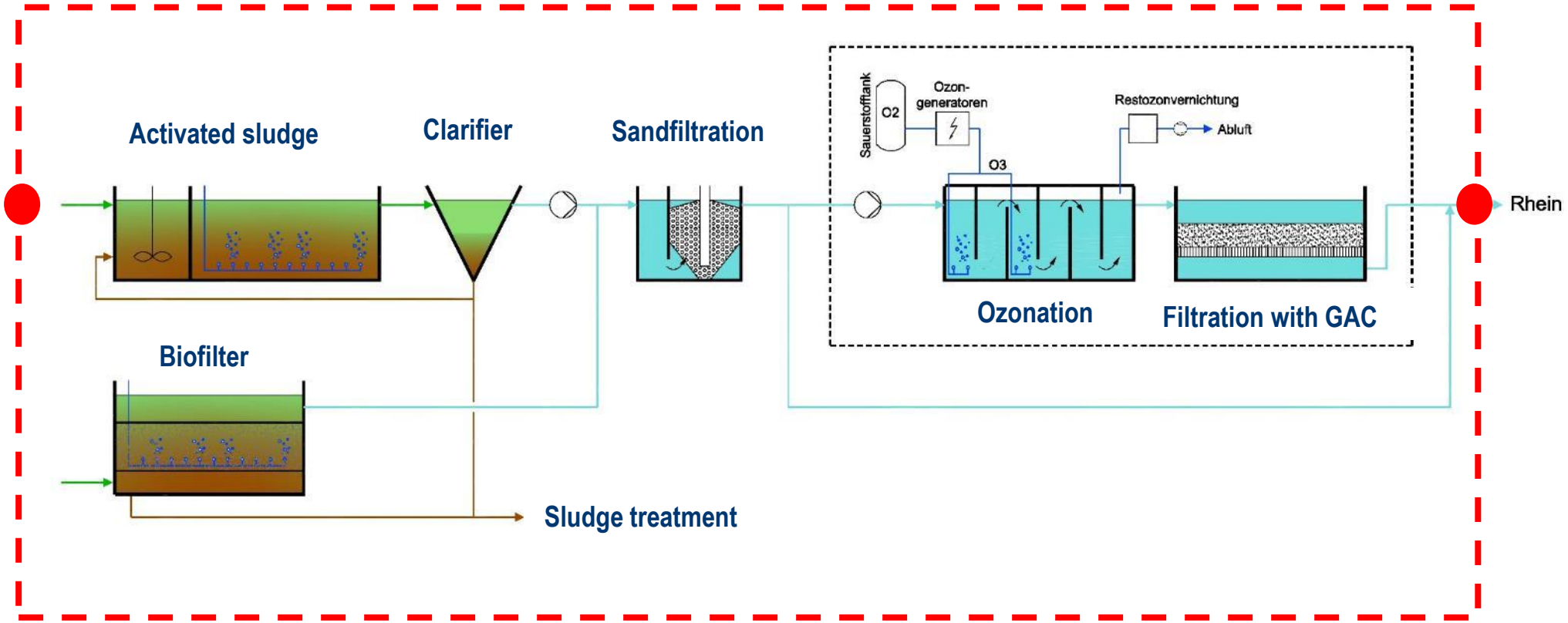
Micropollutants elimination:
Ozonation, and adsorption on granular activated carbon

Sludge treatment:
anaerobic digestion & sludge drying

Altenrhein

Switzerland

Organic micropollutants elimination



>80% Elimination

(average of 12 indicators substaces)

Götz, C.W., R. Kase und J. Hollender (2011). „Mikroverunreinigungen - Beurteilungskonzept für organische Spurenstoffe aus kommunalem Abwasser—. Studie im Auftrag des BAFU. Eawag, Dübendorf

Goals and approch

GOALS:

1. To manufacture GAC from renewables with similar performances as commercial GAC
2. To test renewable GACs for the elimination of organic micropollutants as tertiary treatment at pilot scale

APPROACH:

1. Laboratory and pilot experiments to investigate the effect of pyrolysis and activation on GAC performances
2. Production of 2 two GACs from renewable resource
3. Operation and monitoring of 2 GAC fixed bed filters for 8-12 months

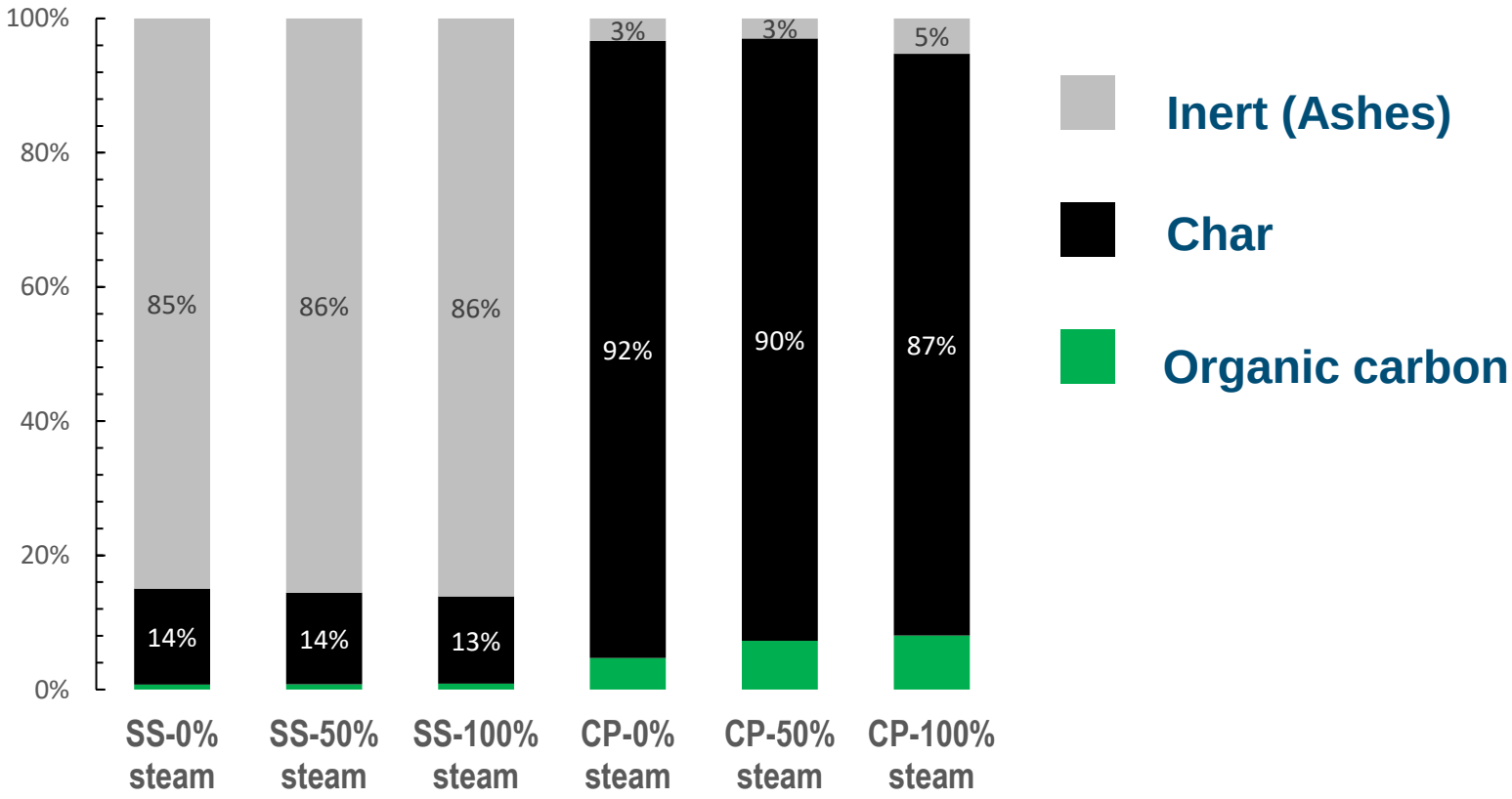
Production of GACs from renewables

Phase	Objectives
Pilot trials	To generate samples under different conditions: • 2 renewable resources (Cherry pits and Sewage sludge) • Temperature of pyrolisis and activation (700, 800, 900°C) • Activation gas (CO_2, H_2O) • Residence time (10, 20, 30')
Characterization of samples	To assess properties and performances: • Yield of production and ash content • Particle size distribution • Density • Hardness • Specific surface, and porous size distribution • Adsorption (SAC254, OMPs)

Results: Renewable granular activated carbon (GAC)

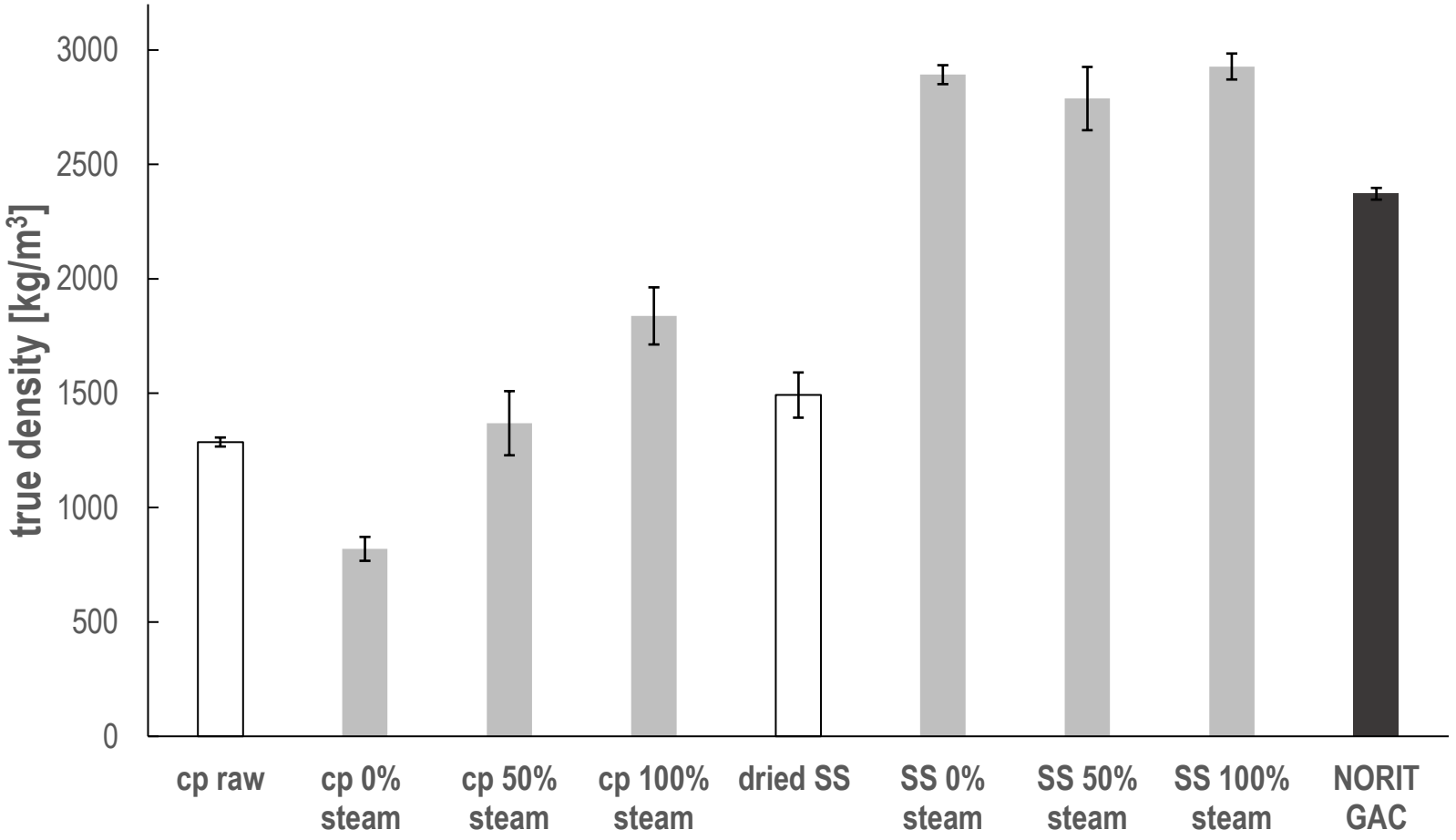
Thermogravimetric analyis of pilot materials activated at 900°C for 10’ with H_2O

- Sewage sludge GAC (SS) with 10-15% «anorganic carbon» content
- Cherry pit GAC (CP) with 90% «anorganic carbon» content



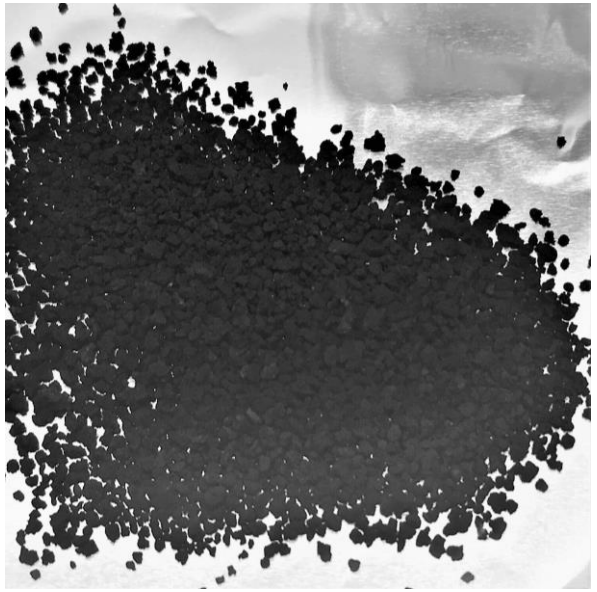
Results: Renewable granular activated carbon

Sewage sludge GAC with higher density than reference
Cherry pit GAC with lower density than reference

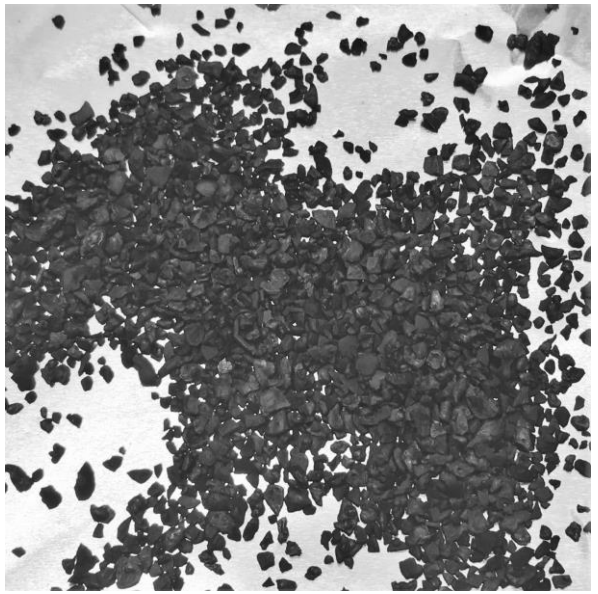


The $GAC_{sewage\ sludge}$ and $GAC_{Cherry\ pits}$

Sample name	Cond.	SAK adsorption [%]	total area [m^2/g]	total porous volume [m^3/g]	PB hardness [%]	tap density [kg/m^3]	Production yield [%]
SS GAC	CO_2_800°C	9	534	0.176	**87**	592	50
CP GAC	H_2O_900°C	**17**	678	0.398	63.3	260	13
401V	-	23	722	Unk.	>90	490	Unk.

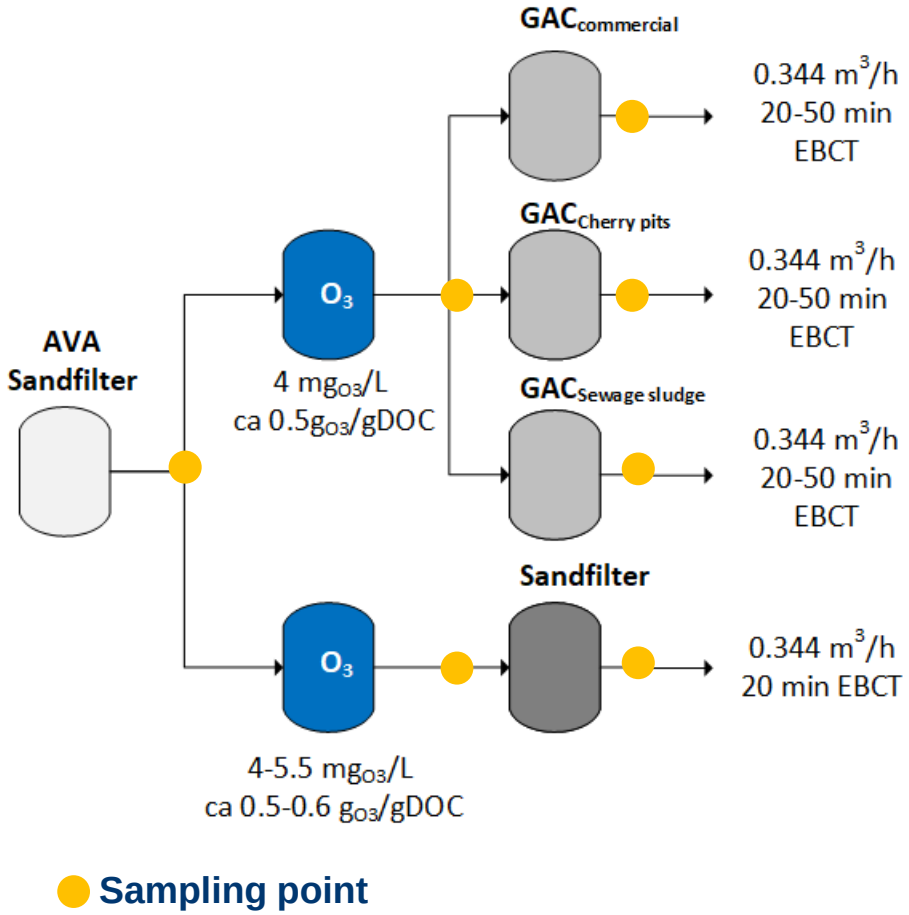


$GAC_{Sewage\ sludge}$



$GAC_{Cherrypits}$

The Ozone and GAC pilot plant



Filter 1	Chemviron 401V (401V)
Filter 2	Cherry pit GAC NextGen (CP Nextgen)
Filter 3	Sewage sludge GAC NextGen (SS Nextgen)
	Sampling point

The Ozone and GAC pilot plant

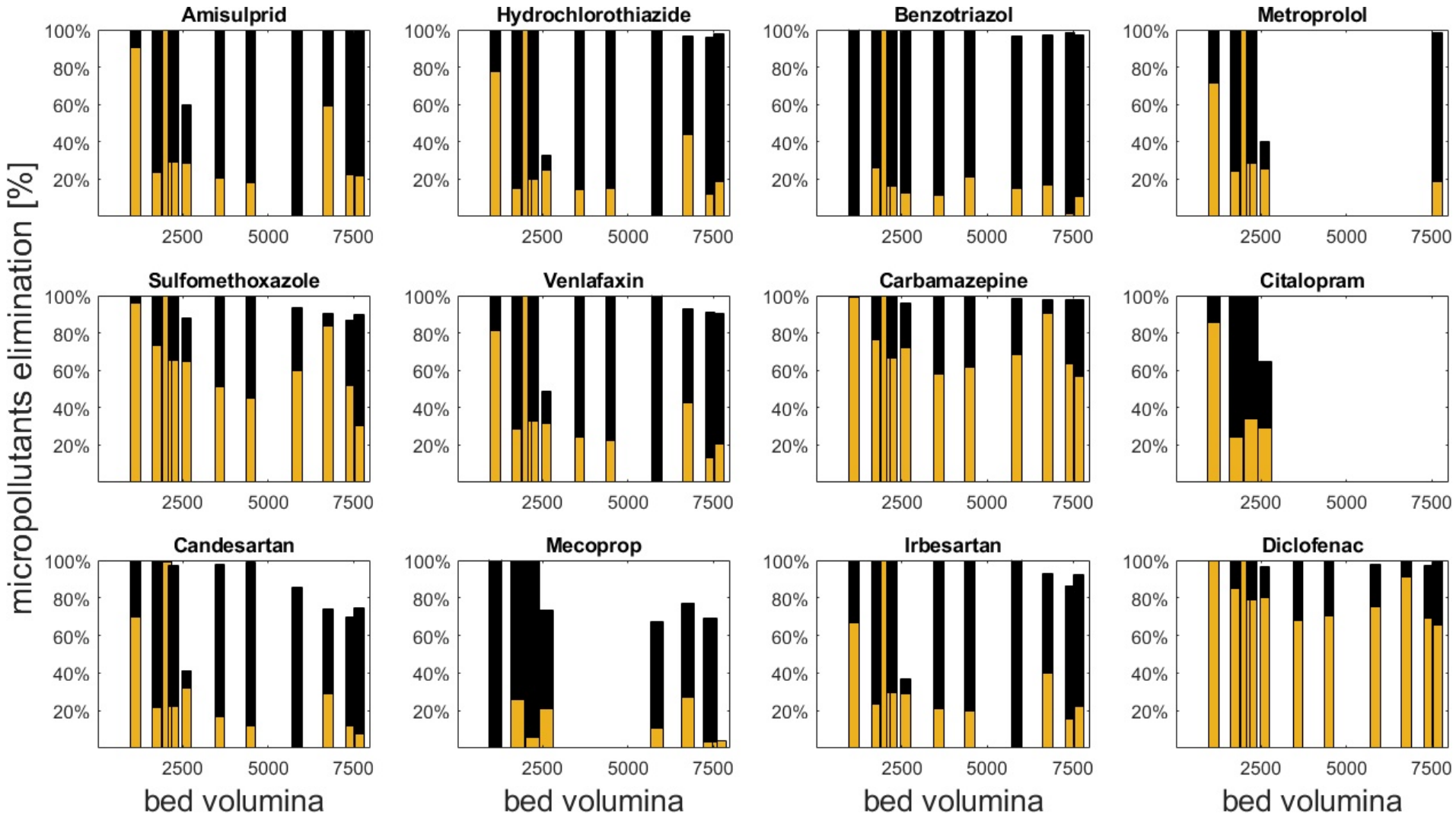
Geometry of the filters		
Diameter of the column	m	0.3
Height of GAK_the fixed bed contactor	m	1.8 – 1.5
Volume of the fixed bed contactor	m^3	0.127
mass of $GAC_{Sewage\ sludge}$	kg	67
mass of $GAC_{Cherry\ pits}$	kg	33
mass of 401V	kg	62

Analytics
SPE - LC MS for organic micropollutants OMP elimination
Sak254 and DOC as proxy for OMPs

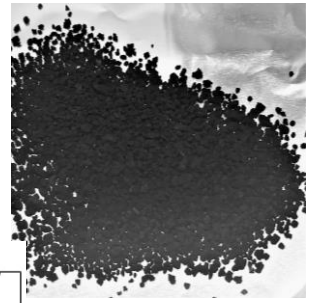
- Automated backwashing system
- Automated sampling at the outlet

Organic micropollutants elimination

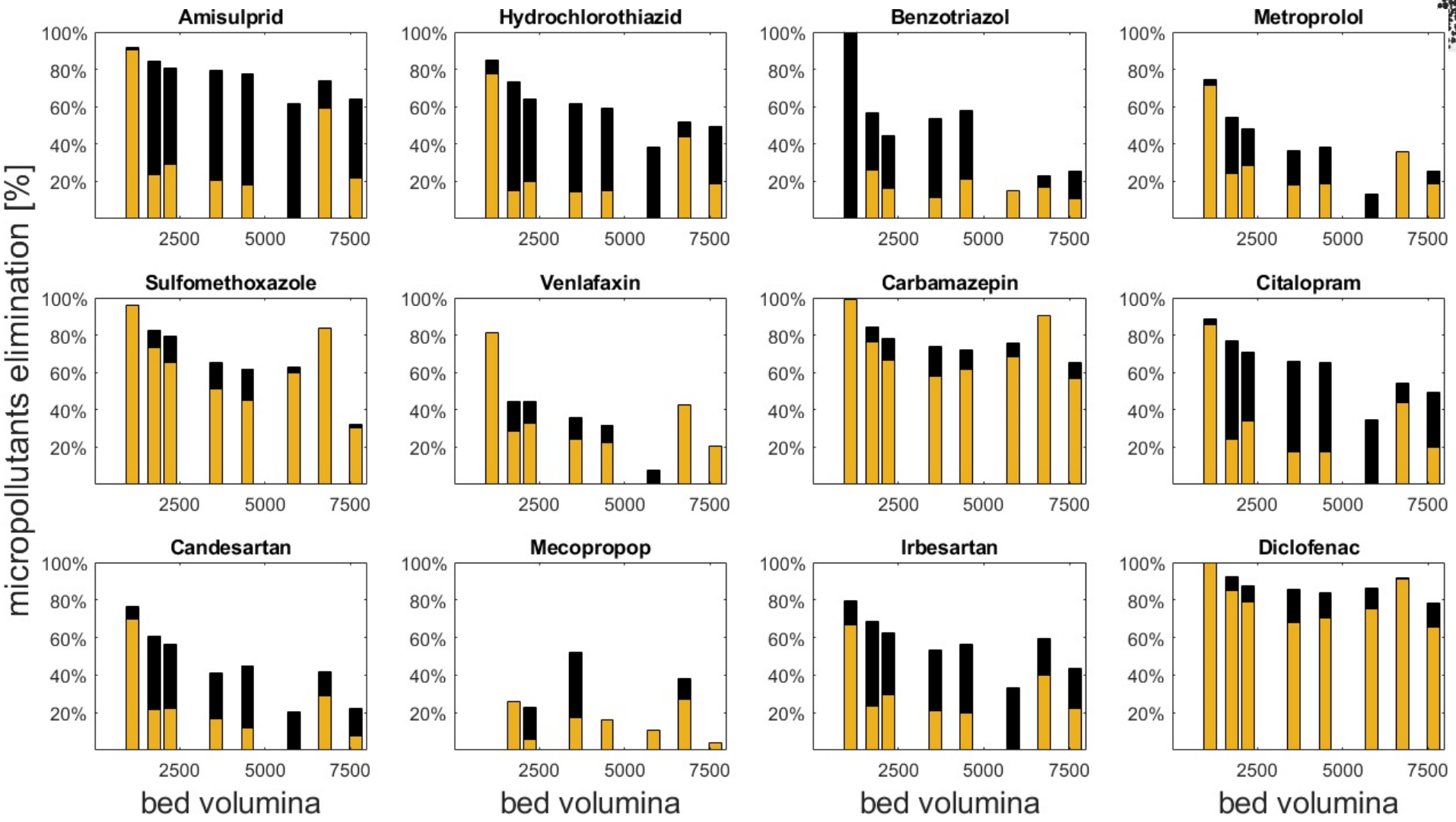
$GAC_{commercial}$ - Chemviron 401V



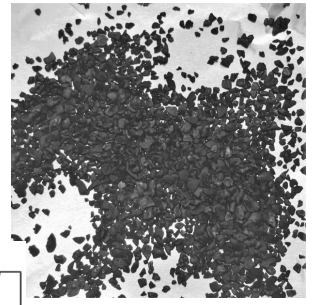
Organic micropollutants elimination



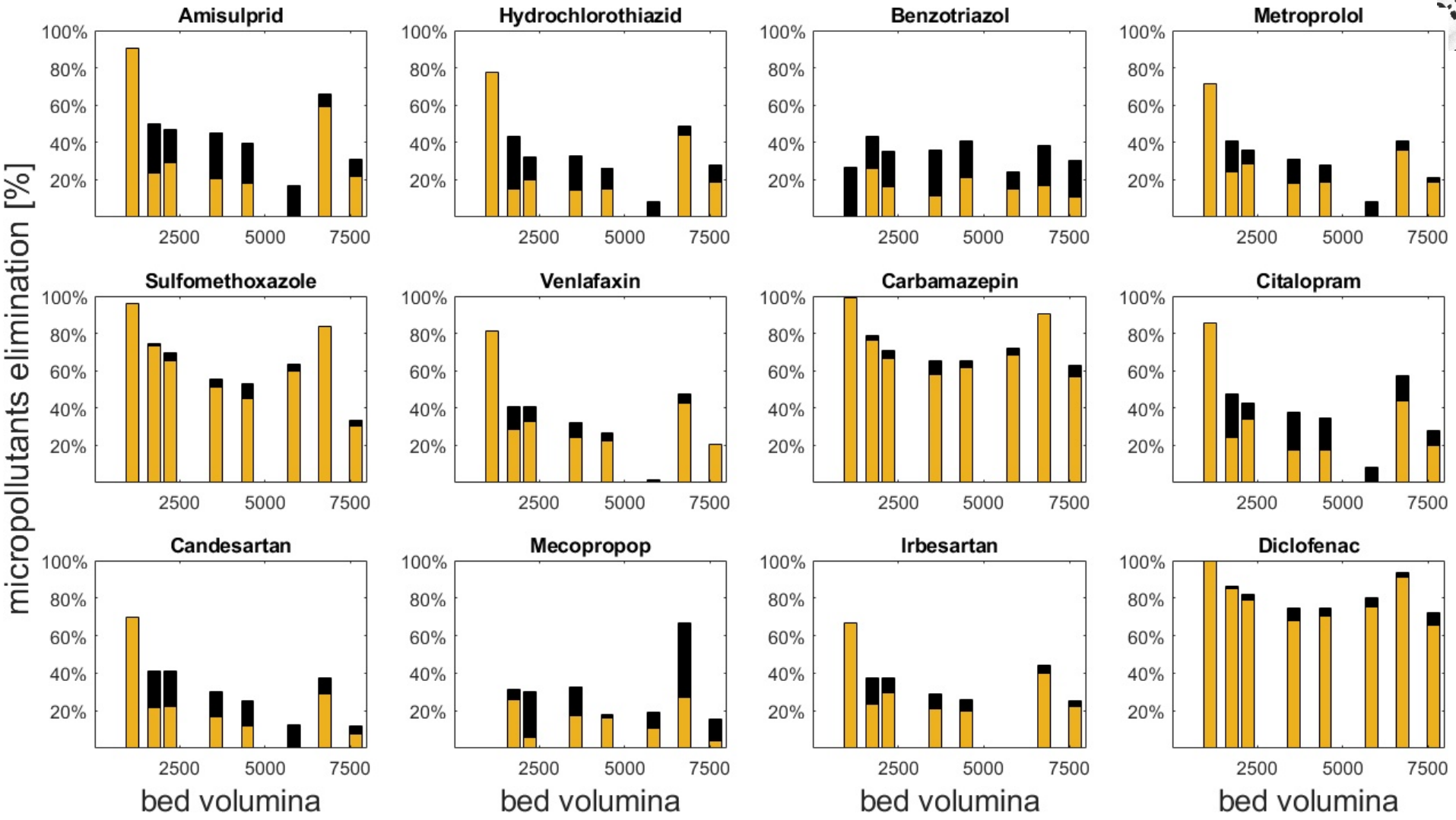
$GAC_{Sewage\ sludge}$



Organic micropollutants elimination

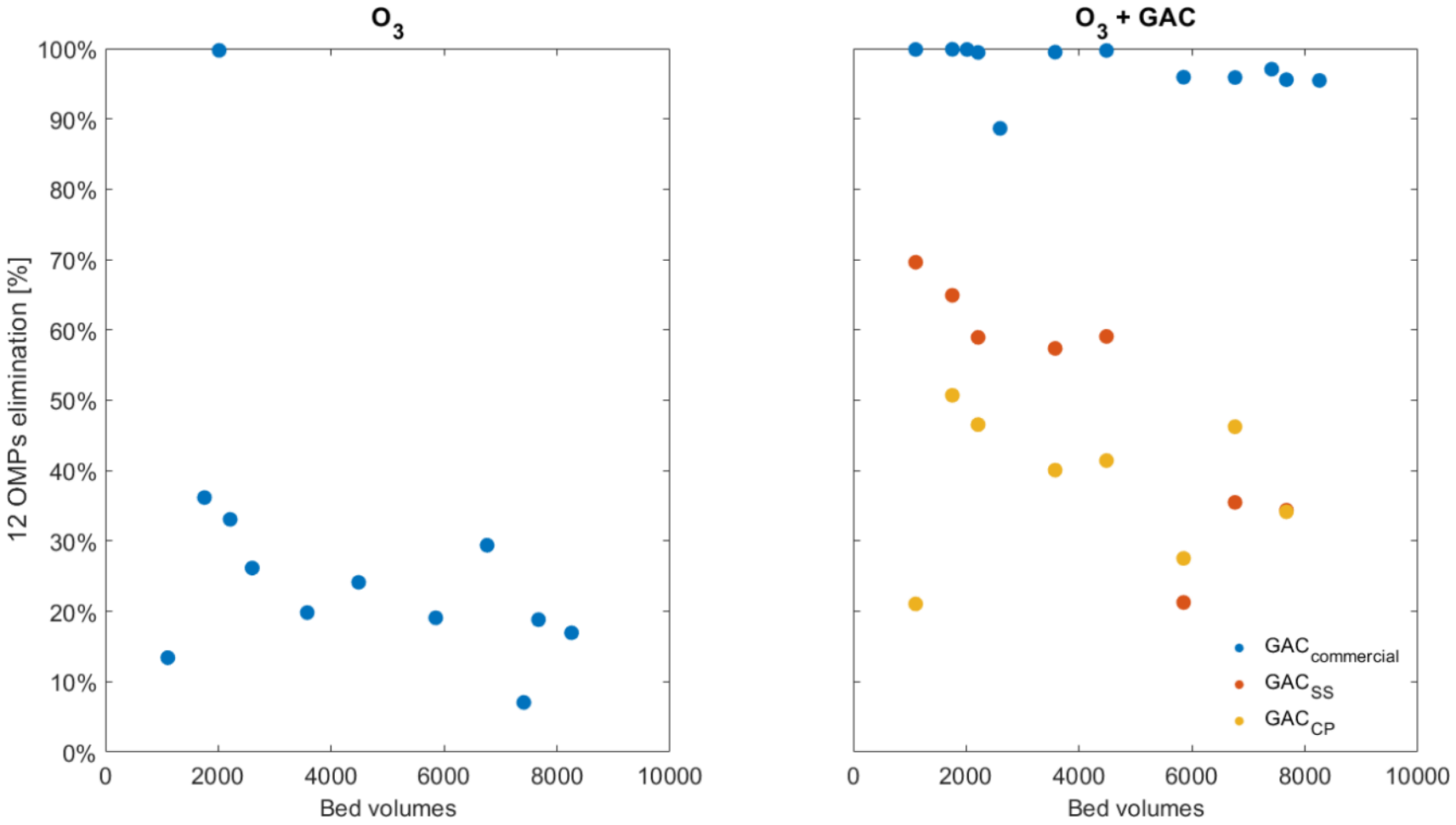


$GAC_{Cherry\ pits}$

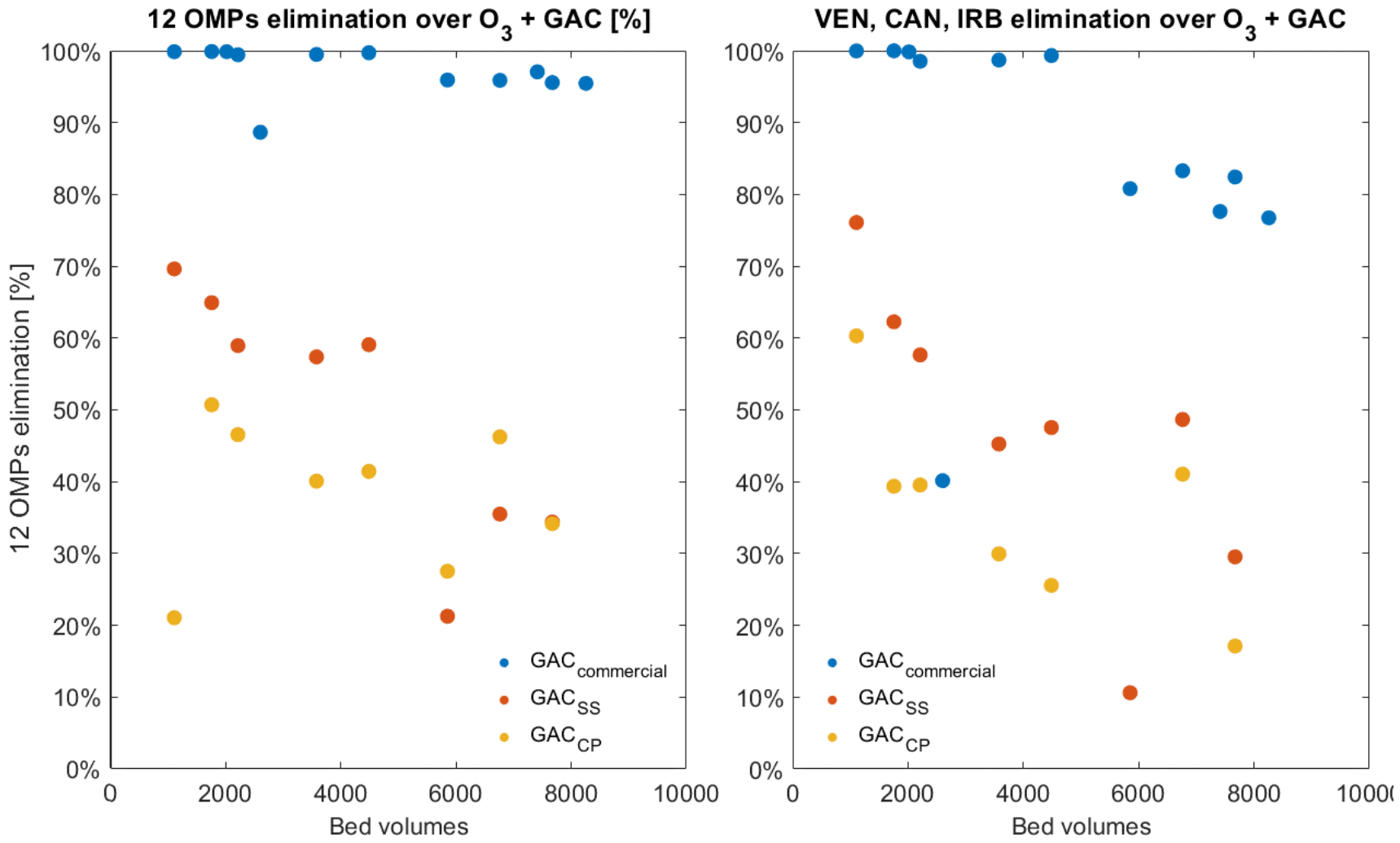


O_3 degradation + GAC adsorption

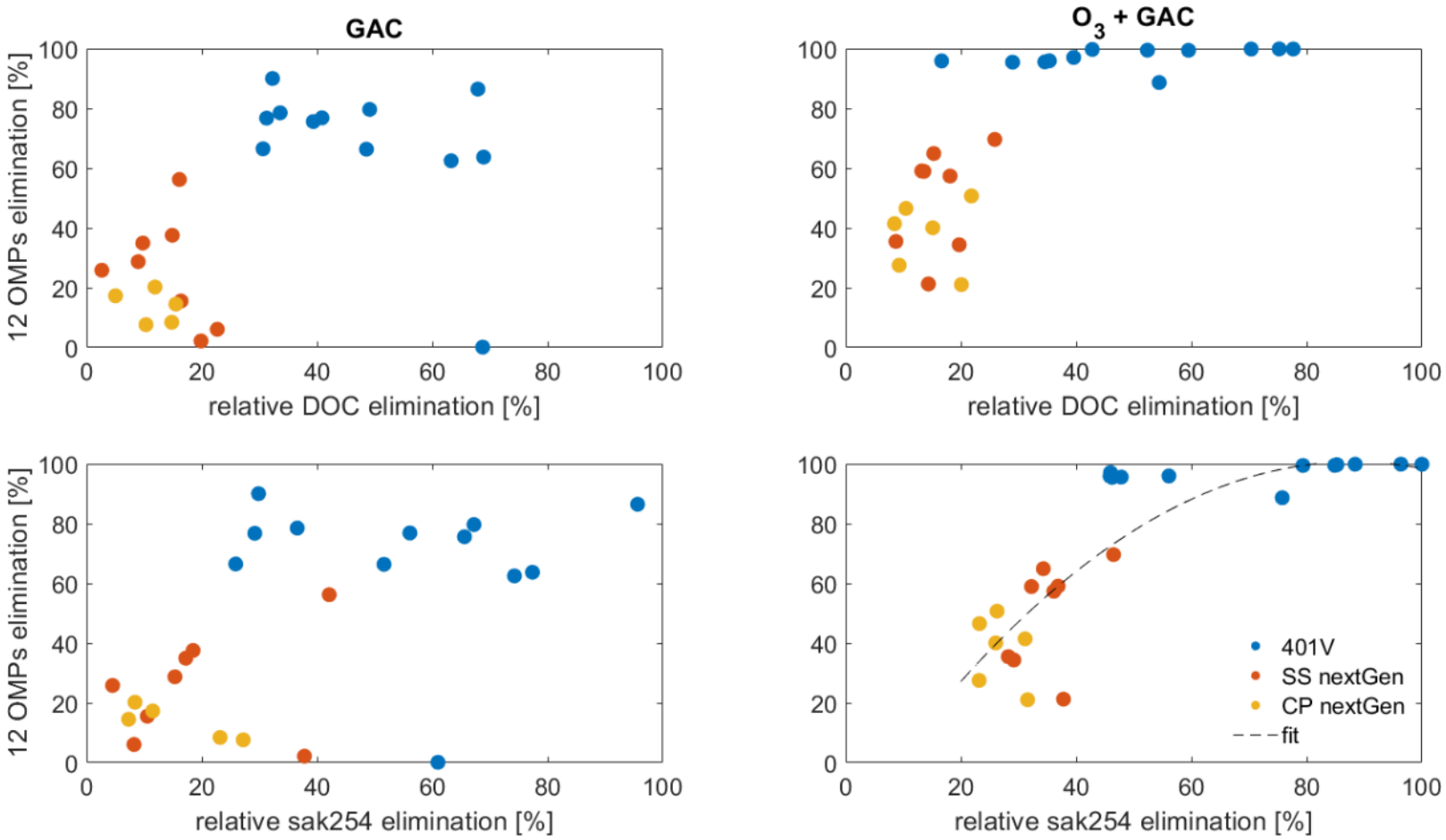
Overall elimination of organic micropollutants



Overall elimination of organic micropollutants and worst case



SAC254 and DOC elimination



SAC254 and DOC elimination are not accurate proxies for monitoring of micropollutants elimination in wastewater

Conclusions

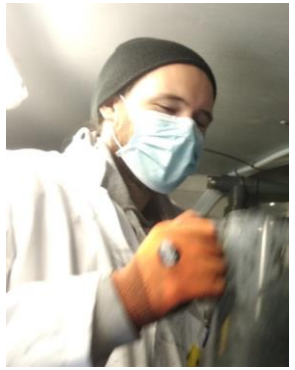
- We identified and manufacture two GACs from renewables sources to be tested at pilot scale
- After 6 months of operation, the first results indicate elimination of some OMPs via GAC filter when use in combination with ozone
- Standard operating conditions do not ensure sufficient elimination as demanded in Swiss ordinance (i.e. 80% elimination). Operating conditions of the filters should require further optimization (i.e. EBCT and O_3 dosage)
- Sak254 and DOC are useful but not accurate proxy for OMP elimination. Direct measurements of OMP is always preferable.

Thank you for your attention!

Fachhochschule Nordwestschweiz

M. Thomann

A. Nättorp



D. Gysin

T. Bisang

M. Huspeka

ABWASSERVERBAND ALTENRHEIN

C. Egli

R. Peng

H. Graf

WABAG

W. Goldinger

Contact details

Luca Loreggian

+41 61 228 55 68
luca.loreggian@fhnw.ch

Fachhochschule Nordwestschweiz FHNW
Hochschule für Life Sciences
Institut für Ecopreneurship

Hofackerstrasse 30

CH - 4132 Muttenz

Extra slides

Renewable granular activated carbon (GAC) Pictures and operational procedure

All methods have been tested with two renewable materials (FHNW):

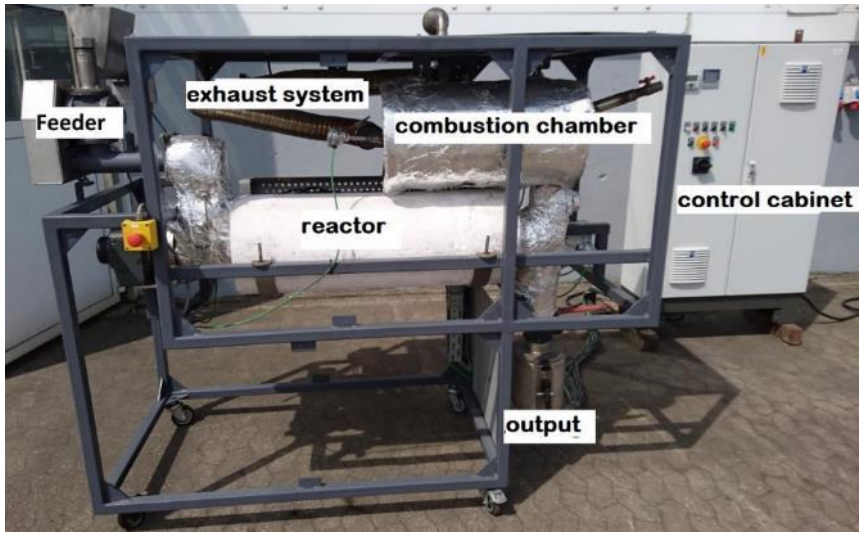
- Pyrolysis
- Activation
- Performance
- Physical and chemical characterization

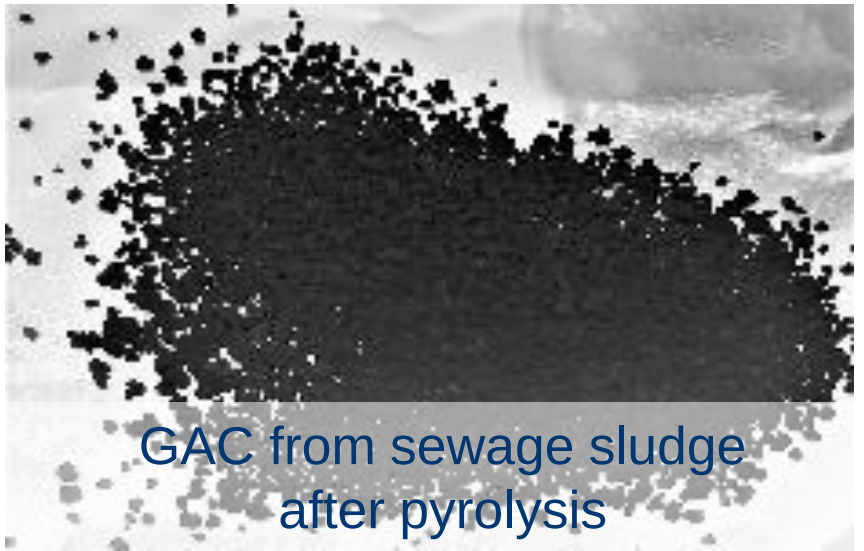
1st phase - Parameter screening

- DSC/TGA plus adsorption (UV 254)
- Upscaling to pilot (1 kg/h) to verify surface area, porosity, hardness, density

2nd phase - Production of optimised GAC

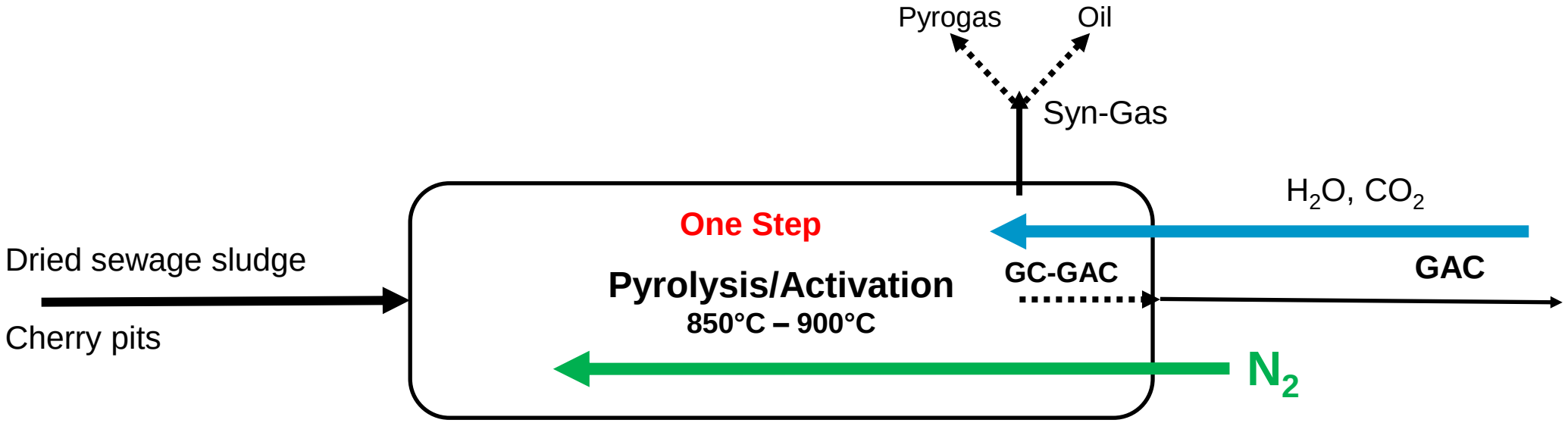
- 2x 150 L
- Sewage sludge, CO_2, 800°C
- Cherry pits, H_2O, 1000°C
- Reference Chemviron Cyclecarb





GAC from sewage sludge after pyrolysis

Renewable granular activated carbon (GAC)
Flow scheme of the pyrolysis



Multiple production parameters are considered:

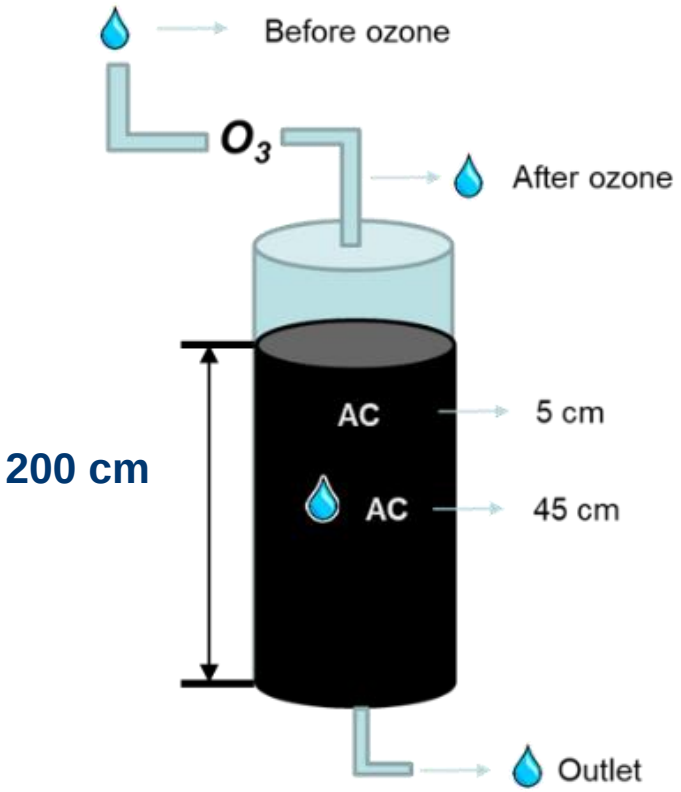
1. **Feedstock material (dried sewage sludge and cherry pits)**
2. **Conditions of pyrolisis and activation (temperature, residence time, activating gas)**

Quality of GAC is assessed based on:

1. **Adsorption capacity**
2. **Physical properties (hardness, surface, porosity, density)**

6. Renewable granular activated carbon (GAC)
Pilot experiments operational procedure

The OMPs elimation of the GAC filters is monitored over time at different operating modes (i.e. EBCT, and O_3 dosage)



Monitoring of the pilots

- Performance of the O_3+GAC system (i.e. Organic micropollutant (OMPs) elimination by LC MS, and UV adsorption)
- Operating period of renewable GAC (i.e. carbon loss in the effluent)
- Biofilm formation (5-7 samples/yr) (TGA, flow cytometry, SEM, NGS)