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SUSTAINABLE WATERS
EMPEREST

Marek Swinarski
Gdańsk Water Utilities

Emperest Workshop #4
May 13th, 2025, Szczecin

Lessons learned from the pilot-scale removal of micropollutants



Ultra-mobile plug-and-play pilot plant dedicated to eliminating MPs from water













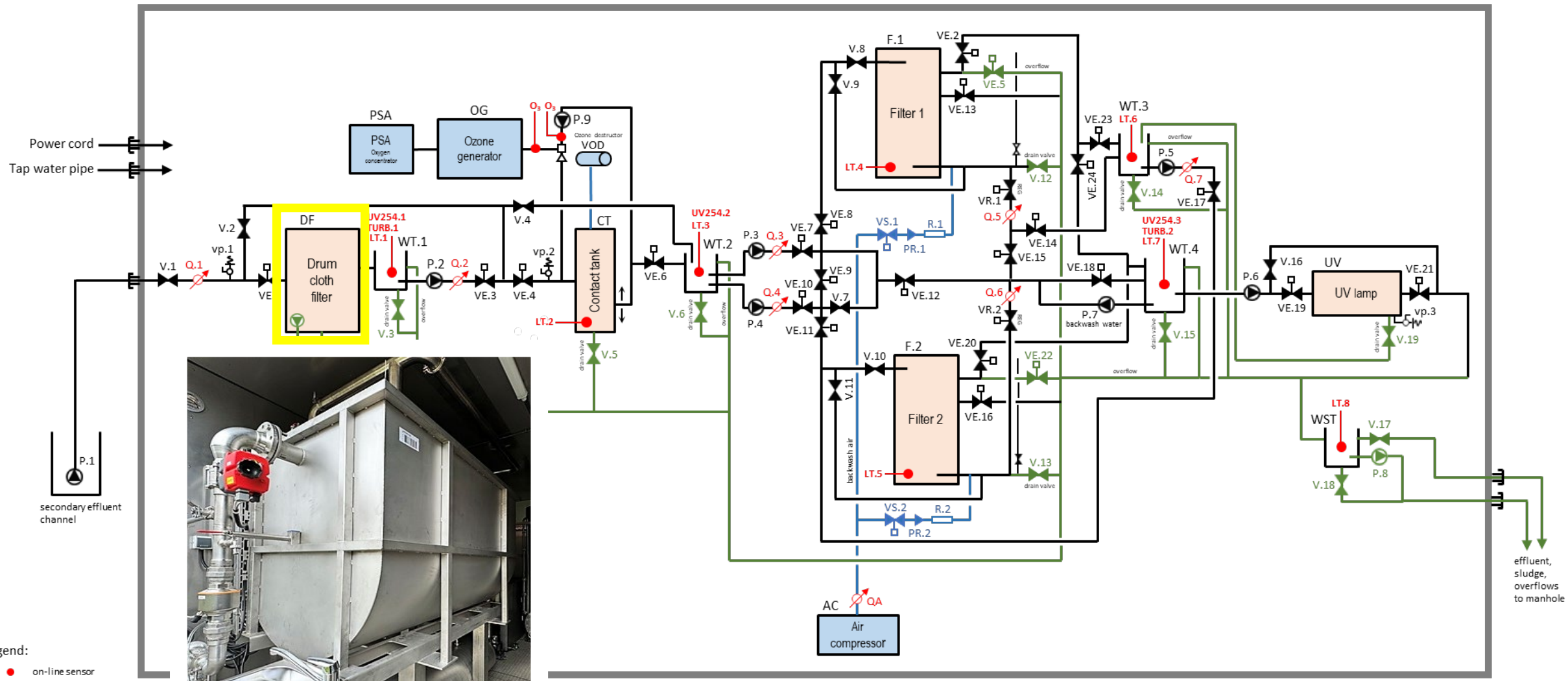
Schematic diagram of the pilot wastewater treatment system

$Q_{P.1}$ = 2.0 – 15 m³/h

$Q_{P.2}$ = 1.0 – 3.1 m³/h

$Q_{P.3}$ = 0.20 – 0.80 m³/h
$Q_{P.4}$ = 0.20 – 0.80 m³/h
$Q_{P.5}$ = 0.17 – 0.60 m³/h

$Q_{P.6}$ = 0.14 – 0.60 m³/h



Legend:

- on-line sensor
- pump
- flow meter
- electric open/close valve
- electric regulating valve
- manual open/close valve
- manual sampling valve

$Q_{P.7}$ = 0.7 – 3.8 m³/h

$Q_{P.8}$ = 2.0 – 15 m³/h

Schematic diagram of the pilot wastewater treatment system





PSA
PSA
Oxygen concentrator

OG
Ozone generator

Power cord

Tap water pipe

$Q_{P.3}$ = 0.20 – 0.80 m³/h
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$Q_{P.6}$ = 0.14 – 0.60 m³/h

$Q_{P.7}$ = 0.7 – 3.8 m³/h

$Q_{P.8}$ = 2.0 – 15 m³/h

P.1
secondary effluent channel

V.1 Q.1 V.2 vp.1 VE.1 DF Drum cloth filter V.20 SS removed

UV254.1 TURB.1 LT.1 WT.1 V.3 P.2 Q.2 VE.3 V.4 vp.2 VE.4 CT Contact tank LT.2 VE.6 V.6

UV254.2 LT.3 WT.2 P.3 Q.3 VE.7 VE.8 VE.9 VE.10 VE.11 P.4 Q.4 V.7 VE.12 VS.1 R.1 PR.1

F.1 Filter 1 LT.4 V.8 V.9 VE.2 VE.5 VE.13 overflow drain valve V.12 VR.1 Q.5 VE.14 VE.15 VR.2 Q.6

F.2 Filter 2 LT.5 V.10 V.11 backwash air VE.20 VE.16 V.13 VE.22 VS.2 R.2 PR.2

VE.23 WT.3 LT.6 VE.24 P.5 Q.7 V.14 VE.17 VE.18 P.7 backwash water UV254.3 TURB.2 LT.7 WT.4 V.15

P.6 V.16 VE.19 UV UV lamp VE.21 vp.3 V.19

LT.8 WST V.17 P.8 V.18

AC Air compressor QA

effluent, sludge, overflows to manhole



Legend:

- on-line sensor
- pump
- flow meter
- electric open/close valve
- electric regulating valve
- rotameter
- pressure reducer
- manual open/close valve
- manual sampling valve

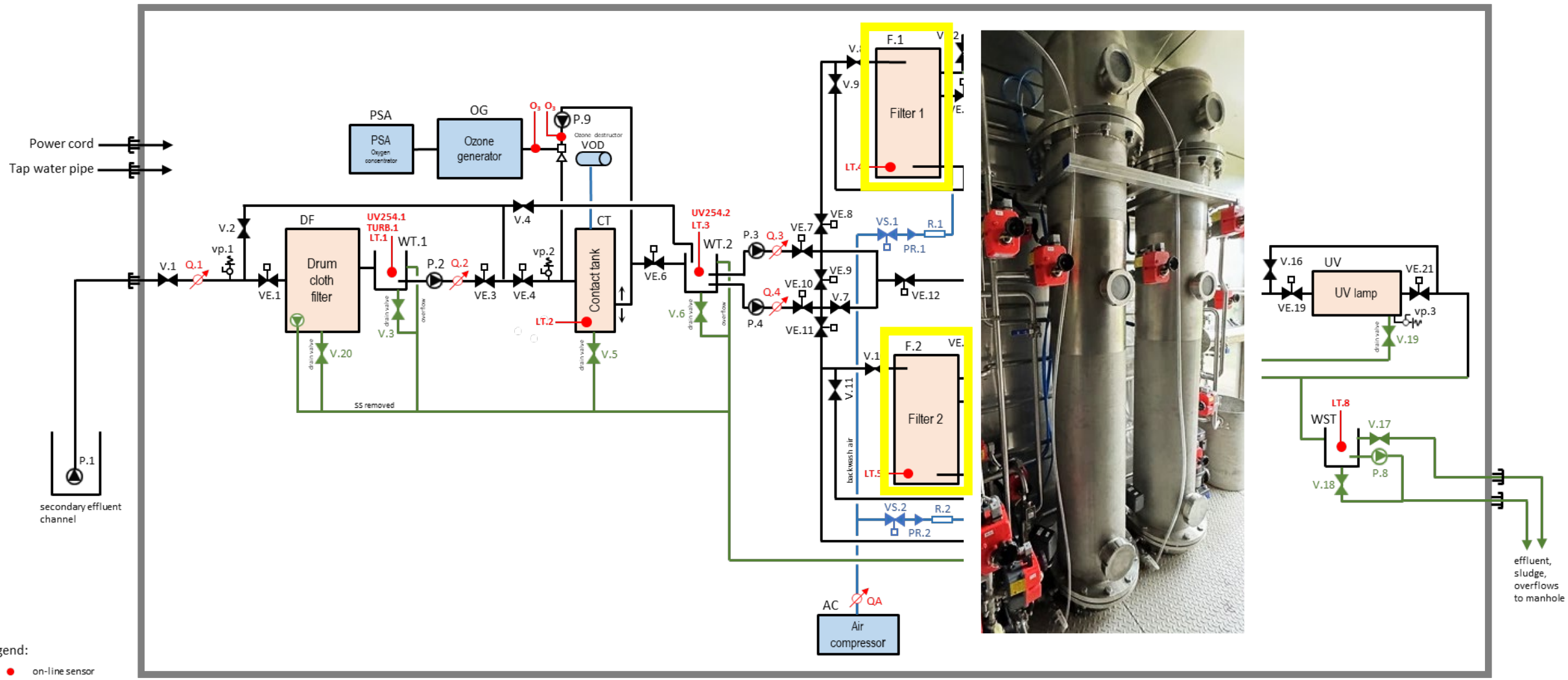
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Legend:

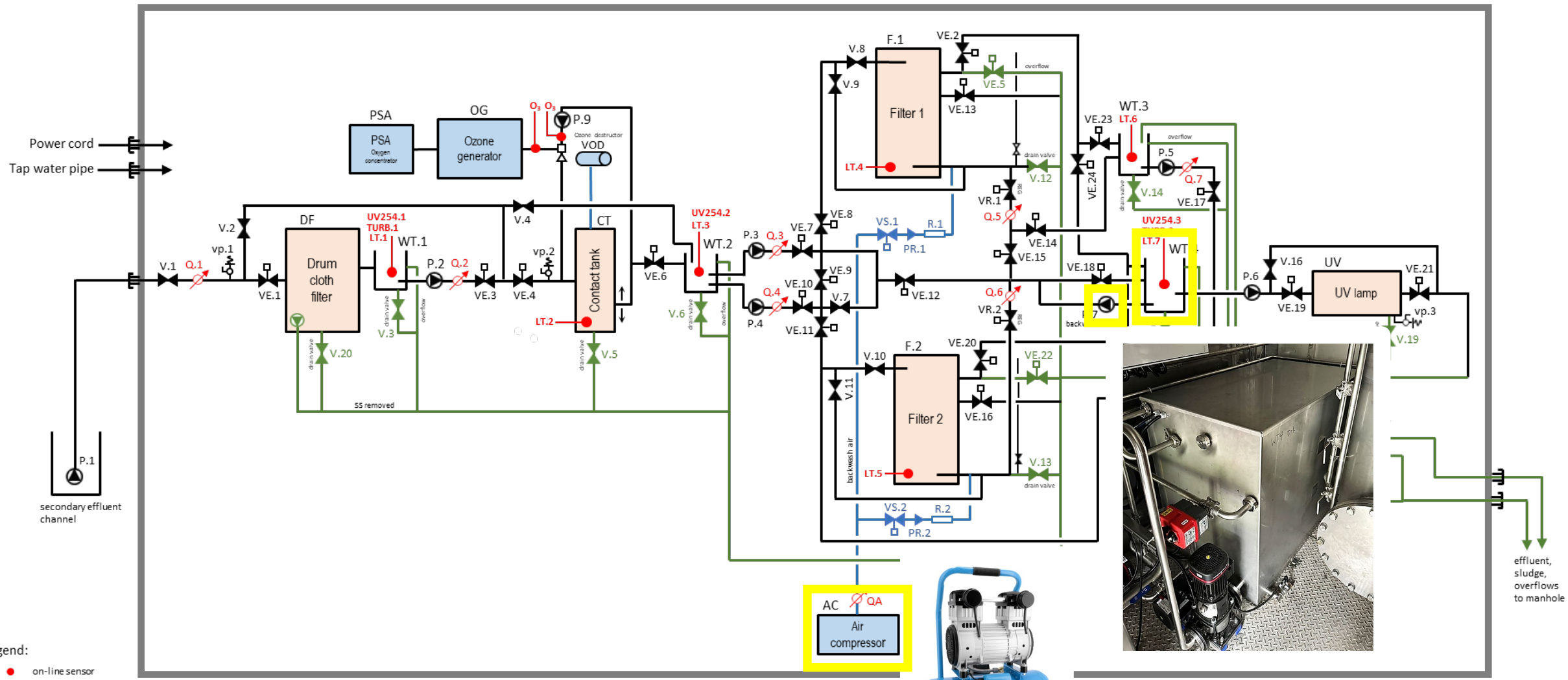
- on-line sensor
- pump
- flow meter
- electric open/close valve
- electric regulating valve
- rotameter
- pressure reducer
- manual open/close valve
- manual sampling valve

$Q_{P.7}$ = 0.7 – 3.8 m³/h

$Q_{P.8}$ = 2.0 – 15 m³/h

Schematic diagram of the pilot wastewater treatment system

$Q_{P.1}$ = 2.0 – 15 m³/h | $Q_{P.2}$ = 1.0 – 3.1 m³/h | $Q_{P.3}$ = 0.20 – 0.80 m³/h, $Q_{P.4}$ = 0.20 – 0.80 m³/h, $Q_{P.5}$ = 0.17 – 0.60 m³/h | $Q_{P.6}$ = 0.14 – 0.60 m³/h | $Q_{P.8}$ = 2.0 – 15 m³/h



Legend:

- on-line sensor
- pump
- flow meter
- electric open/close valve
- electric regulating valve
- rotameter
- pressure reducer
- manual open/close valve
- manual sampling valve

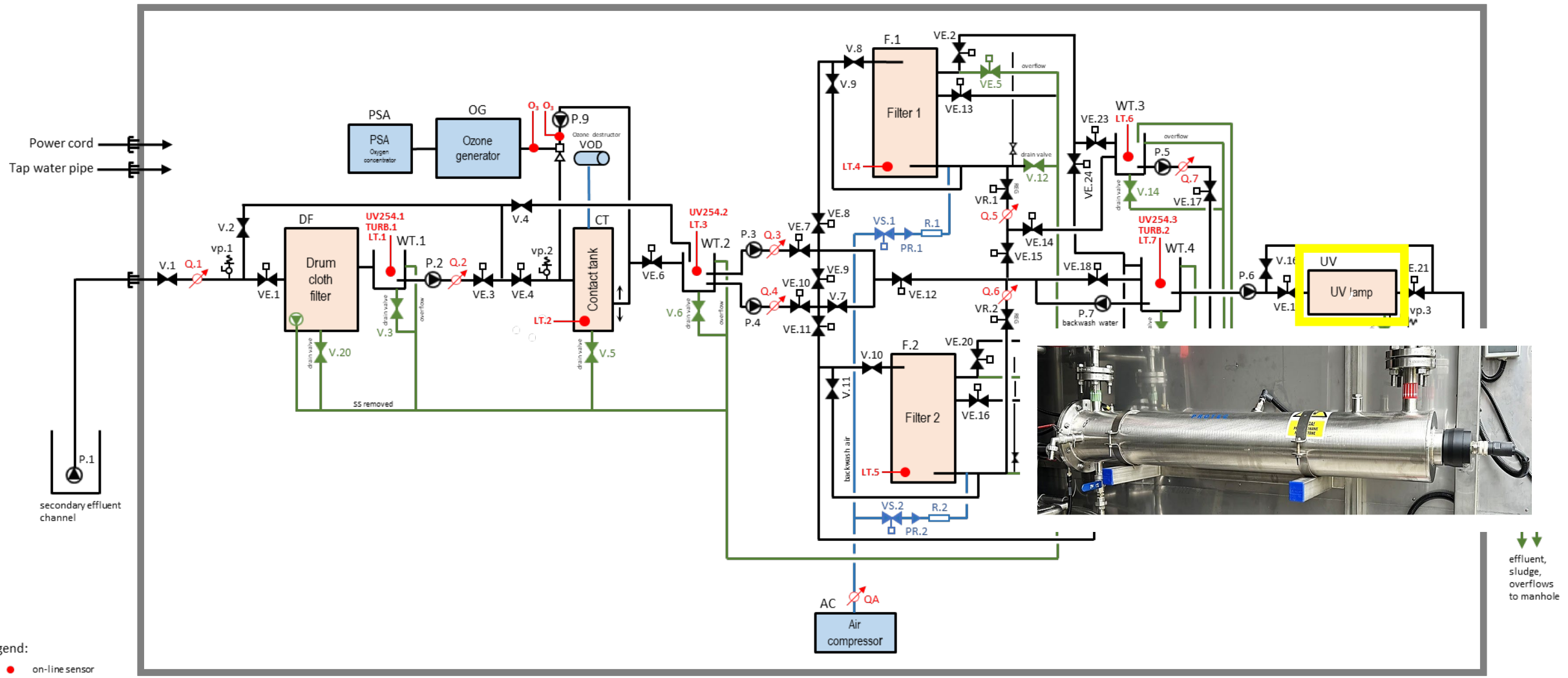
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Legend:

- on-line sensor
- pump
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the pilot wastewater treatment system





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Power cord
Tap water pipe

PSA
PSA Oxygen concentrator
OG
Ozone generator
O_3 O_3
P.9
Ozone destructor
VOD

V.1 Q.1 V.2 vp.1 VE.1
DF
Drum cloth filter
UV254.1 TURB.1 LT.1 WT.1
P.2 Q.2 VE.3 V.3
V.4 vp.2 VE.4
CT
Contact tank
LT.2 V.5
VE.6 V.6
UV254.2 LT.3 WT.2
P.3 Q.3 VE.7 VE.8
P.4 Q.4 VE.10 VE.11
V.20
5S removed

P.1
secondary effluent channel

F.1
Filter 1
V.8 V.9 VE.2 VE.5 VE.13
LT.4
overflow
drain valve
V.12
VE.23 WT.3 LT.6
VE.24
P.5 Q.7 V.14 VE.17
VS.1 R.1 PR.1
Q.5 VE.14 VE.15
VE.9 VE.12
Q.6
VE.18
P.7 backwash water
UV254.3 TURB.2 LT.7 WT.4
V.15
P.6
V.16 UV VE.21
VE.19
UV lamp
vp.3 V.19

F.2
Filter 2
V.10 V.11 VE.20 VE.22 VE.16
backwash air
LT.5
V.13
VS.2 R.2 PR.2

LT.8 WST V.17 P.8 V.18

AC QA
Air compressor

effluent, sludge, overflows to manhole





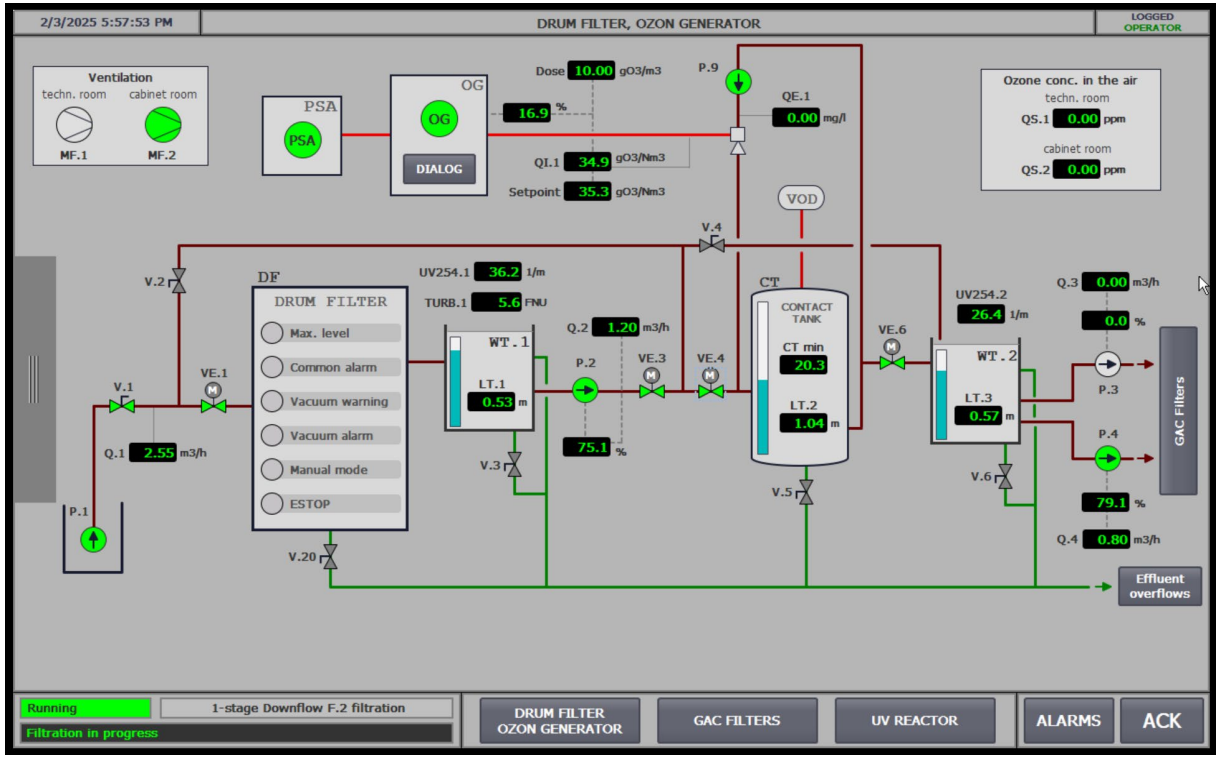


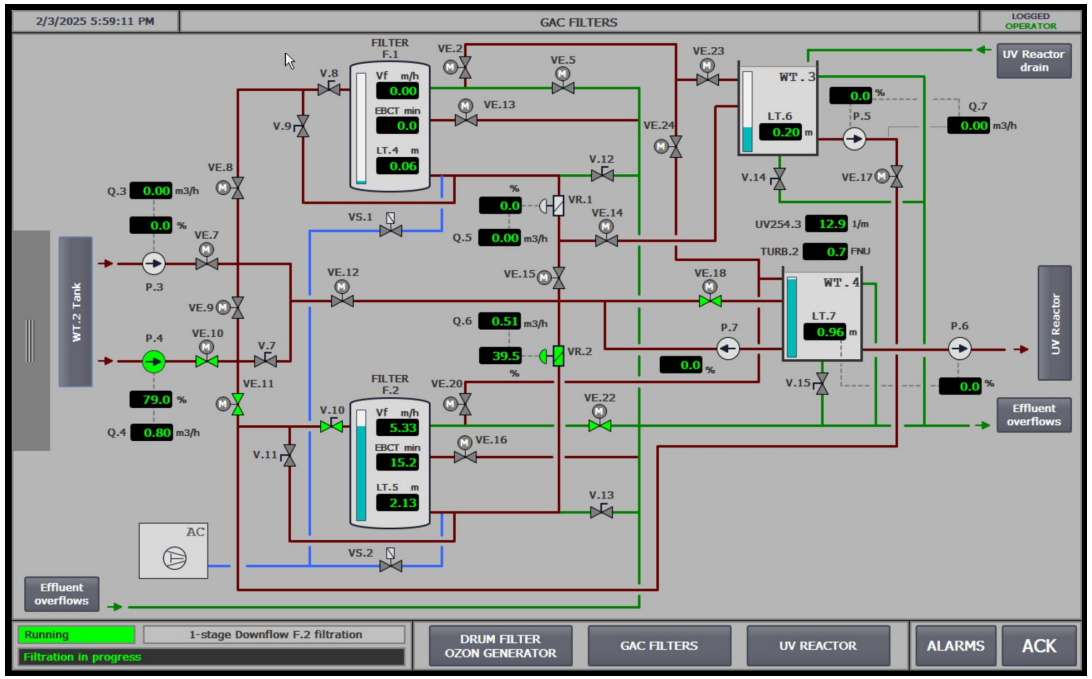
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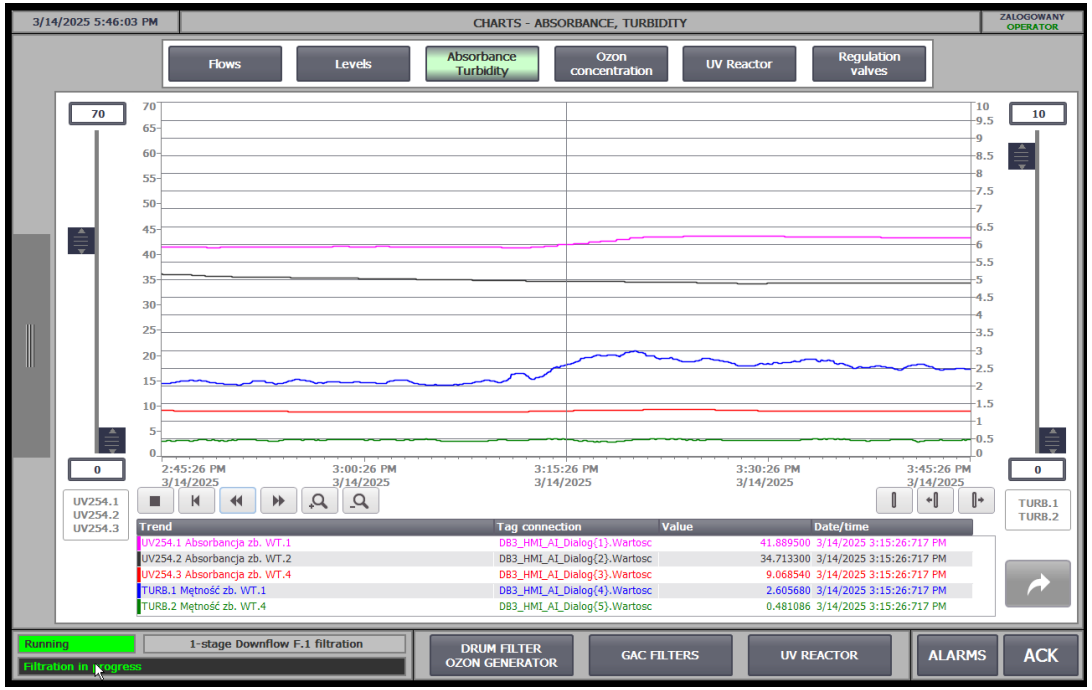
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Monitoring and control system





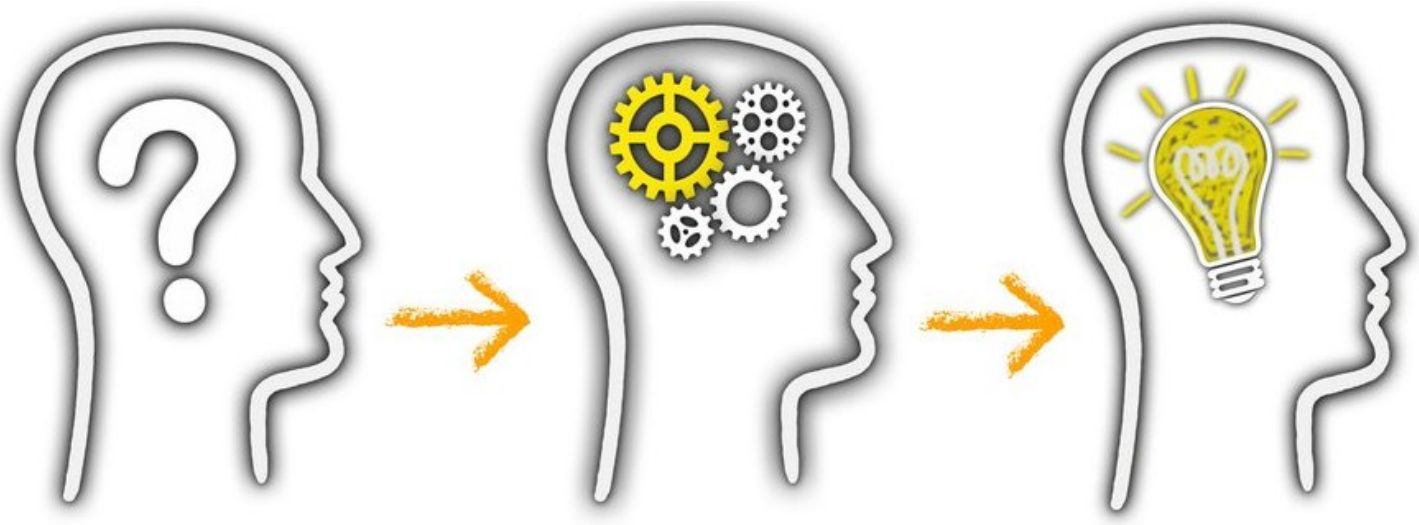


PLC



VPN router





LESSONS LEARNED

Construction cost

Technical features:

- Flexibility
- Control system

Process performance:

- Pre-treatment prior to AOPs
- Optimal process parameters
- Removal efficiency of OMPs

Construction costs

Final construction cost in 2024: **380,000** €

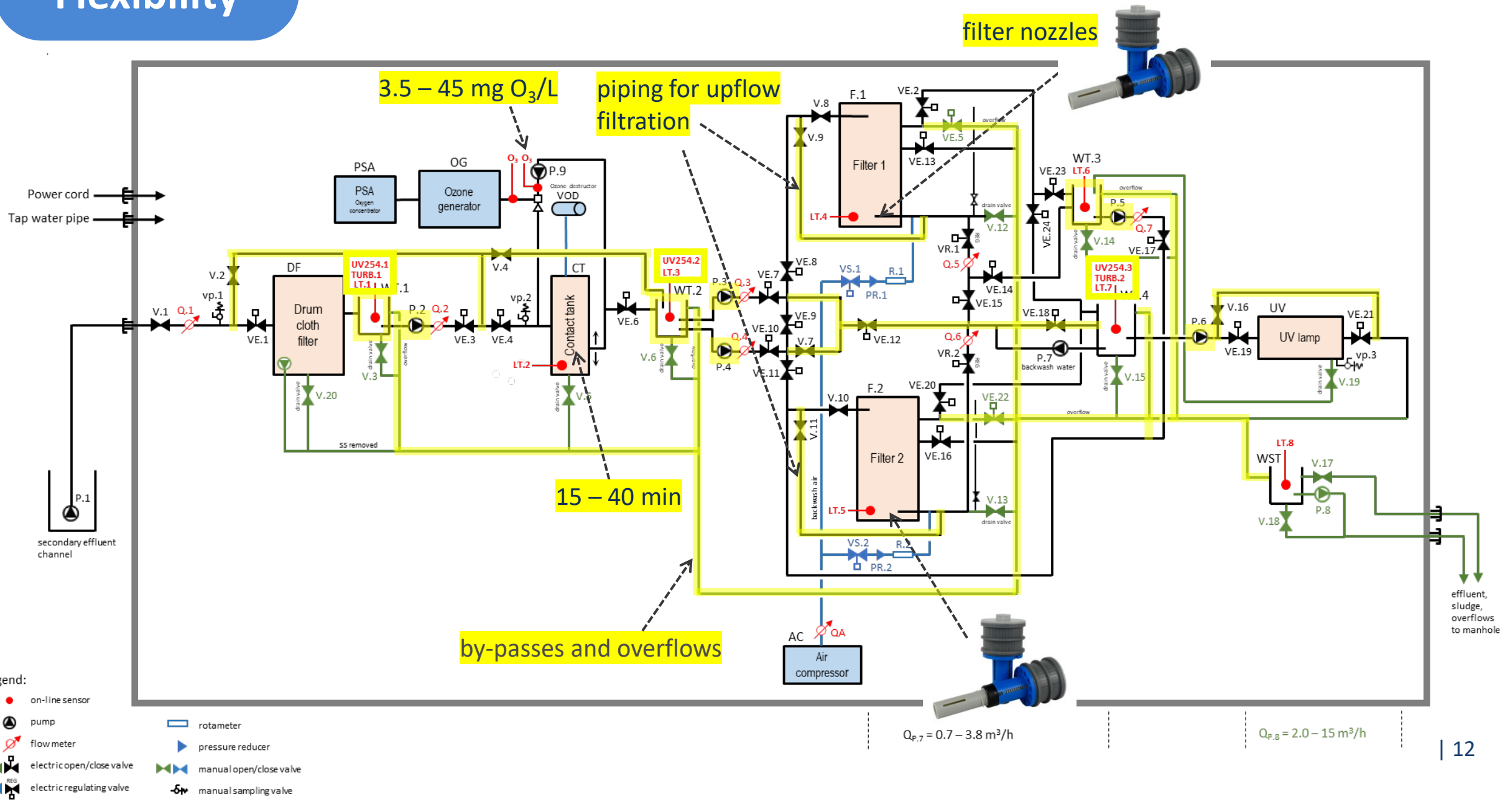




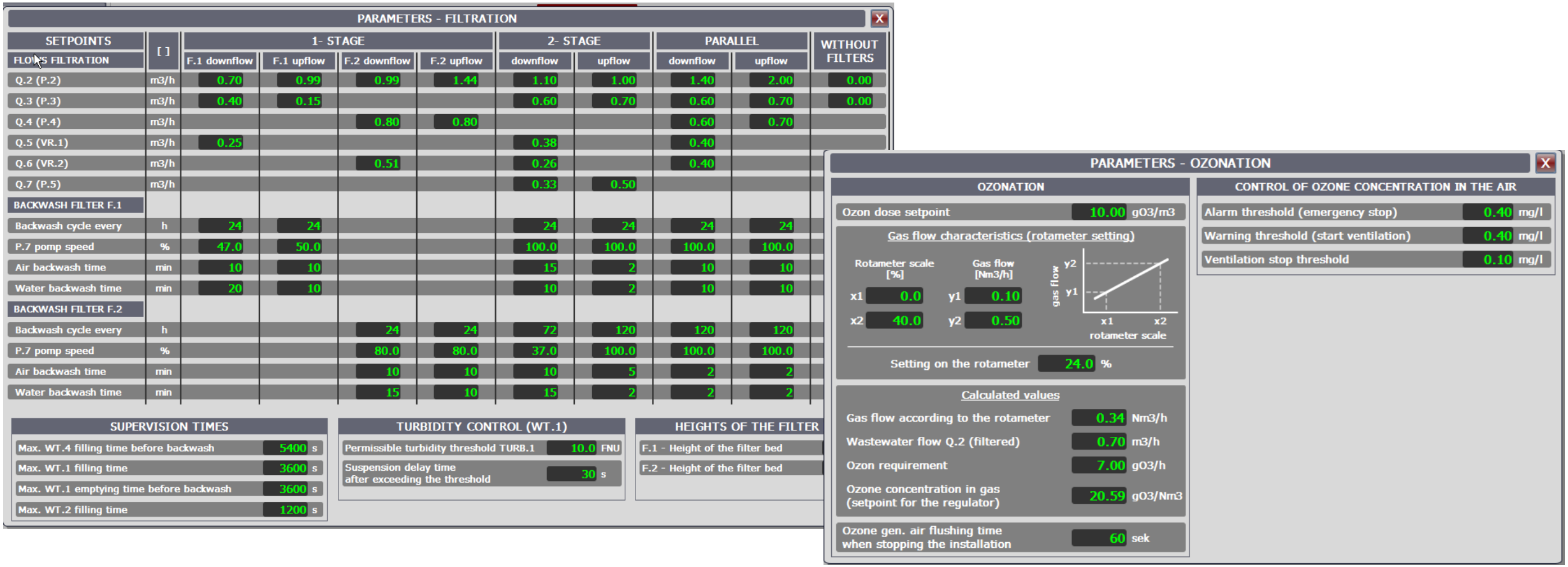
Most expensive elements:

• Ozone oxidation system	90,000 €
• Control system, PLC, HMI panel, router	60,000 €
• On-line UVA and turbidity probes	50,000 €
• Cloth drum filter	45,000 €
• Pumps	25,000 €

Flexibility

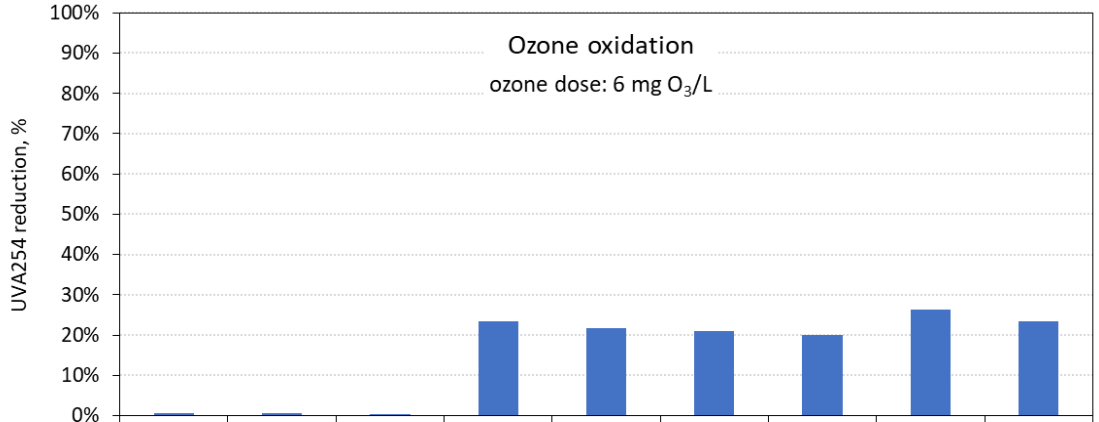


Monitoring and control system



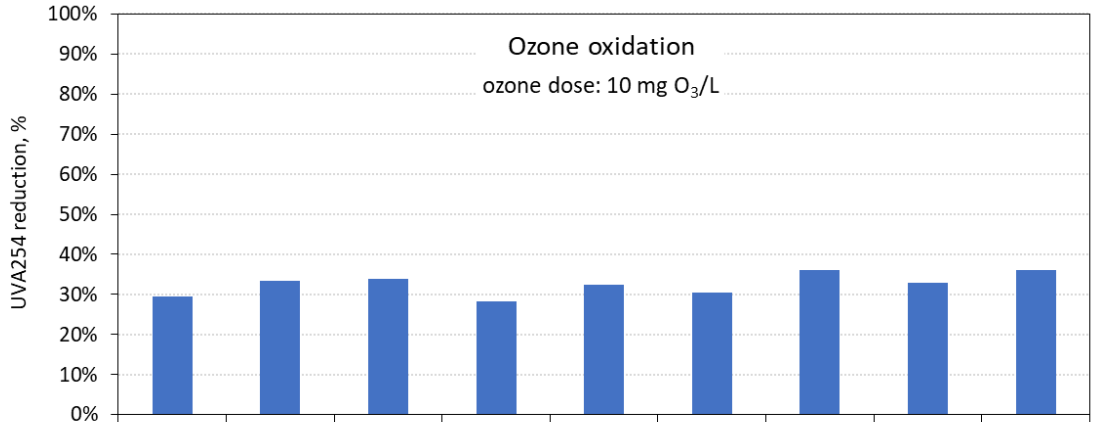
Optimal process parameters

6 mg O_3/L or 0.6 mg O_3/mg DOC

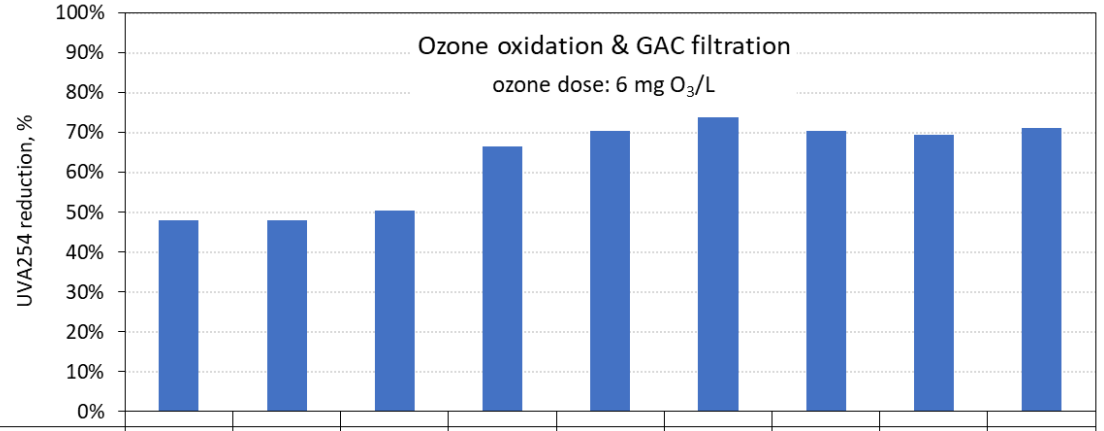


UVA254 reduction	0.6%	0.6%	0.3%	23%	22%	21%	20%	26%	23%
Ozone contact time (min)	15	15	15	30	30	30	40	40	40

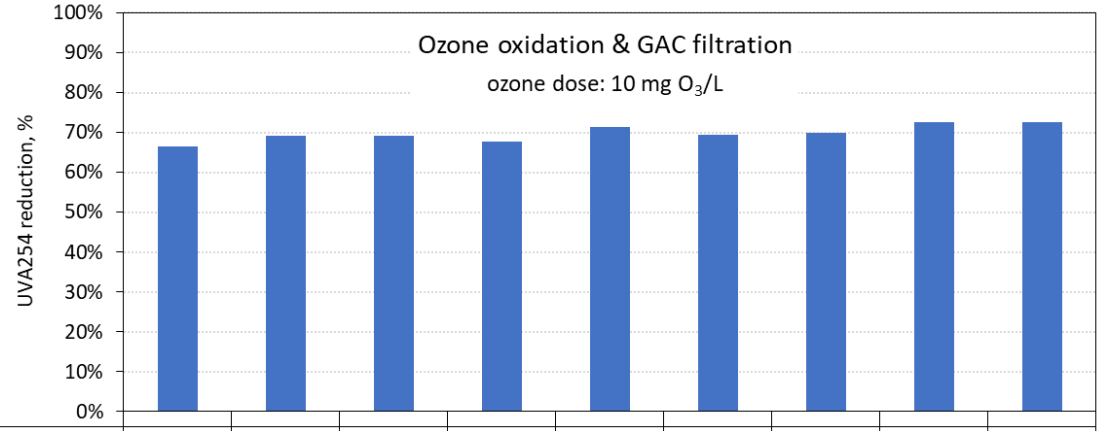
10 mg O_3/L or 1.0 mg O_3/mg DOC



UVA254 reduction	29%	33%	34%	28%	32%	30%	36%	33%	36%
Ozone contact time (min)	30	30	30	30	30	30	30	30	30



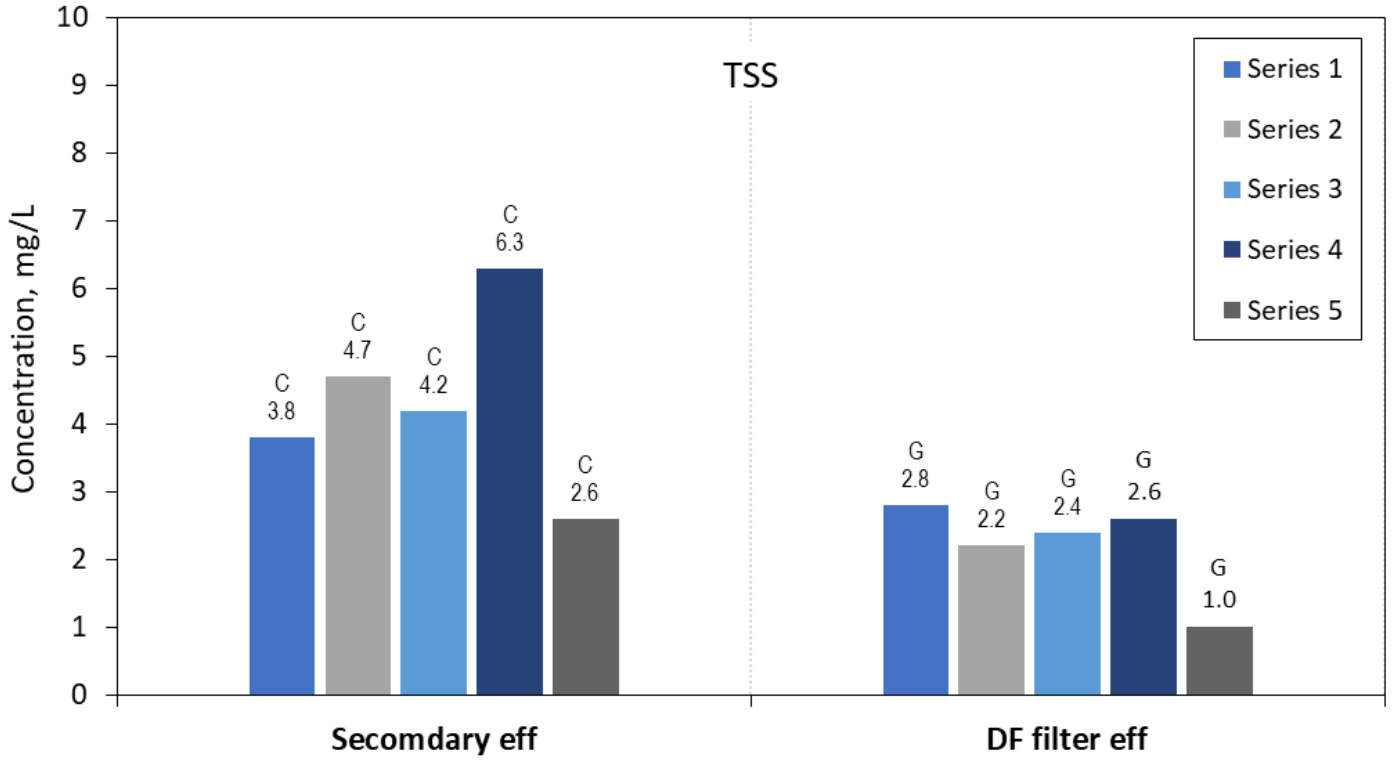
UVA254 reduction	48%	48%	50%	66%	70%	74%	70%	69%	71%
Ozone contact time (min)	15	15	15	30	30	30	40	40	40
EBCT (min)	20	30	40	20	30	40	20	30	40



UVA254 reduction	67%	69%	69%	68%	71%	70%	70%	73%	73%
Ozone contact time (min)	30	30	30	30	30	30	30	30	30
EBCT (min)	20	20	20	30	30	30	40	40	40

Pre-treatment of wastewater

- Reduced ozone demand
- Reduced energy consumption
- Enhanced efficiency of oxidation proces
- Extended lifspan of GAC

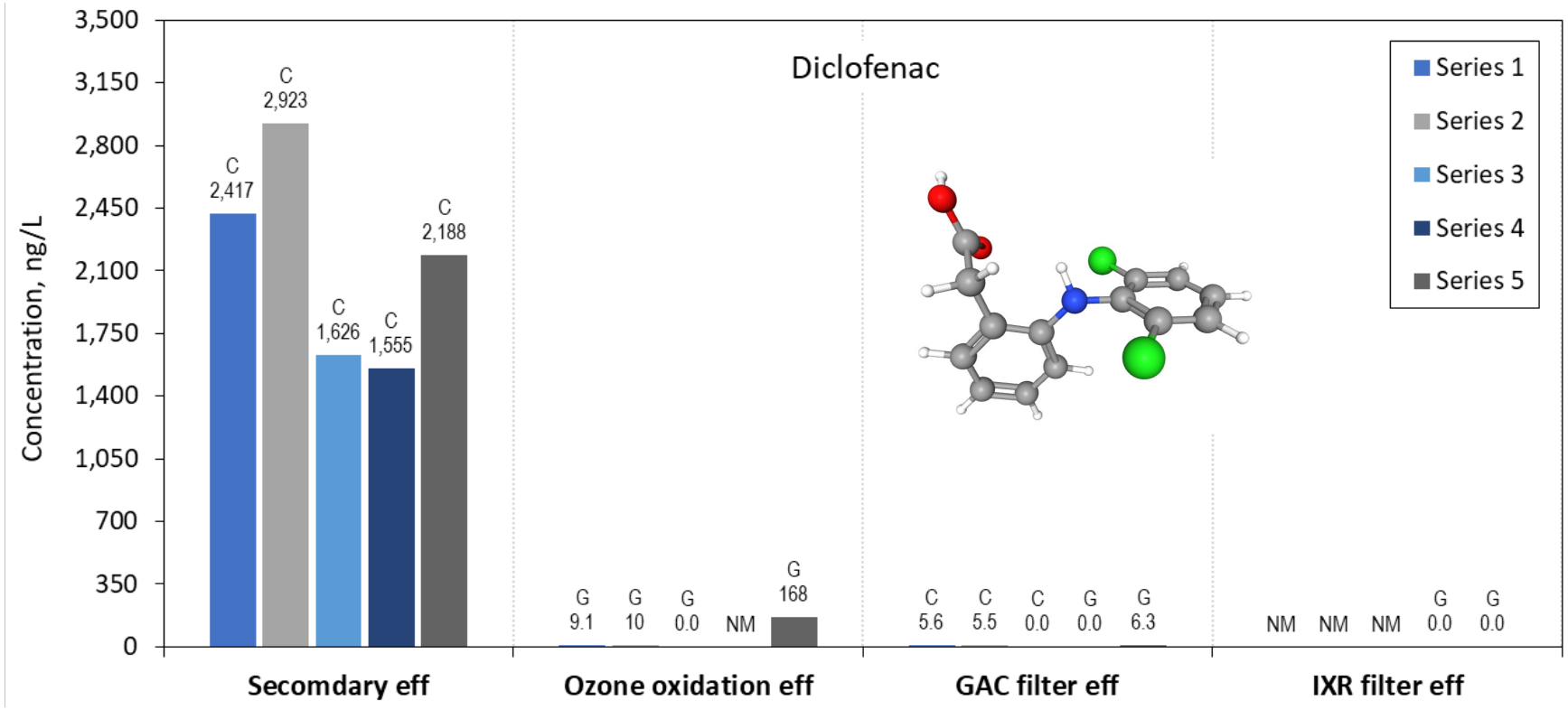




Removal of pharmaceuticals



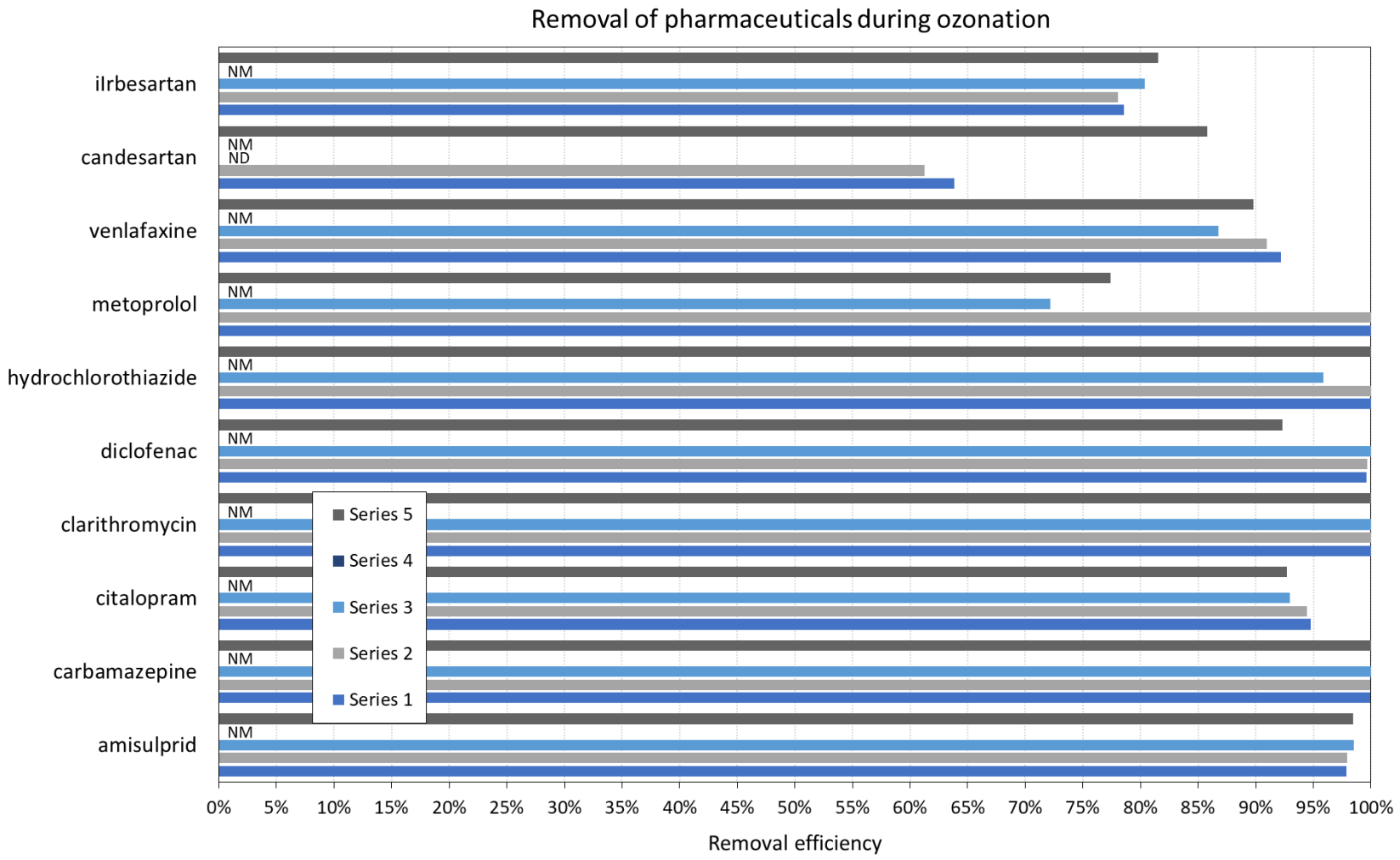
Removal efficiency of diclofenac
1,0 g O_3/g DOC, 30 min ozone contact time



Removal of pharmaceuticals



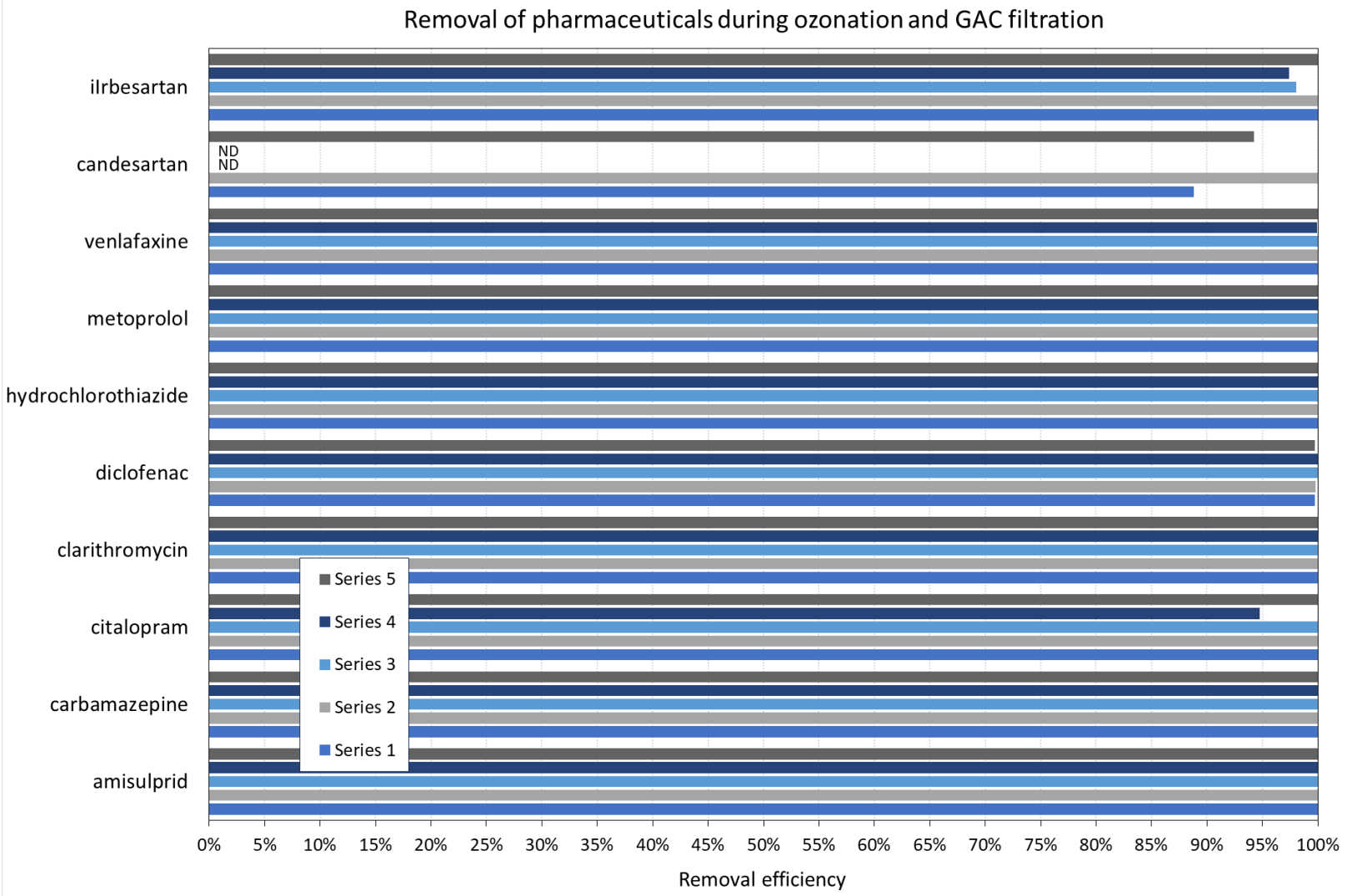
Removal efficiency of pharmaceuticals by ozonation:
1,0 g O_3/g DOC, 30 min ozone contact time



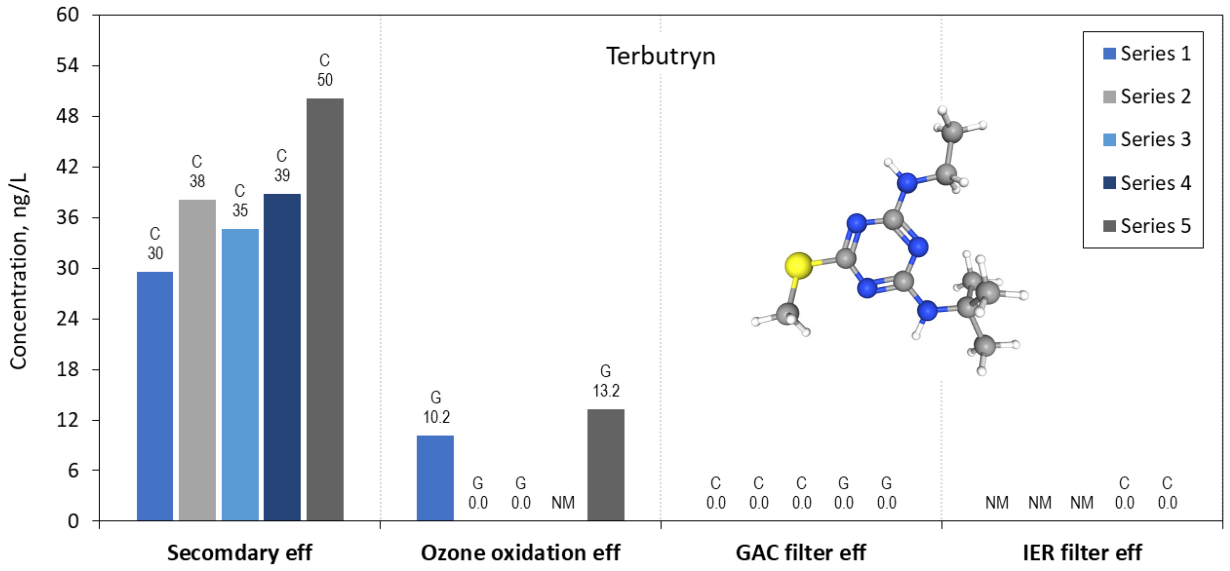
Removal of pharmaceuticals

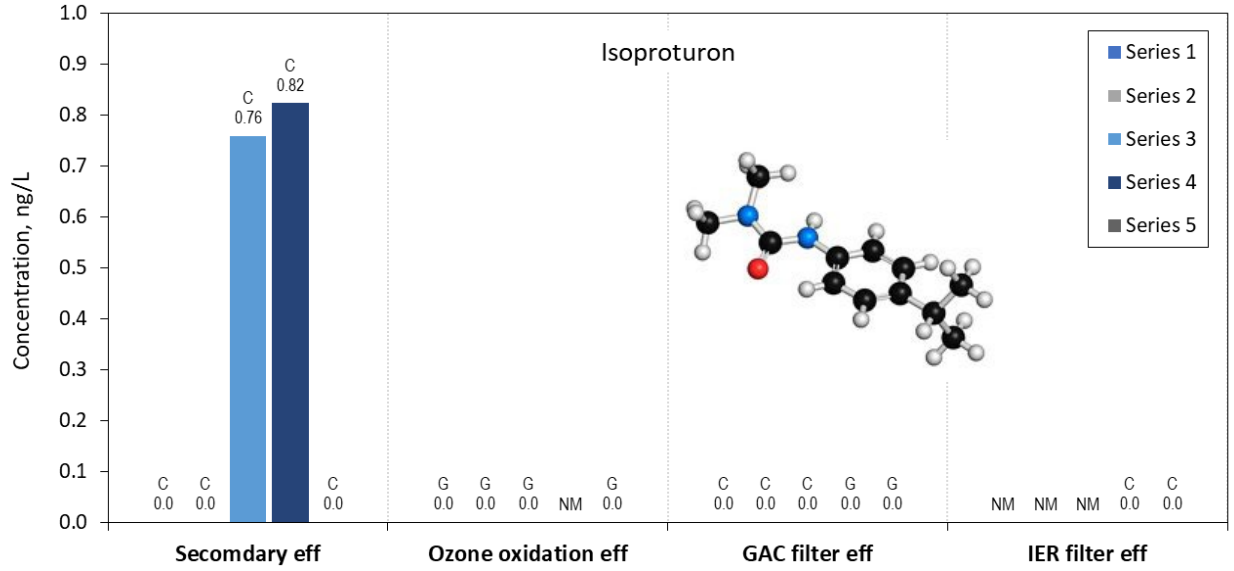


Removal efficiency of pharmaceuticals by ozonation & GAC filtration:
1,0 g O_3/g DOC, 30 min ozone contact time, 20 min EBCT of GAC

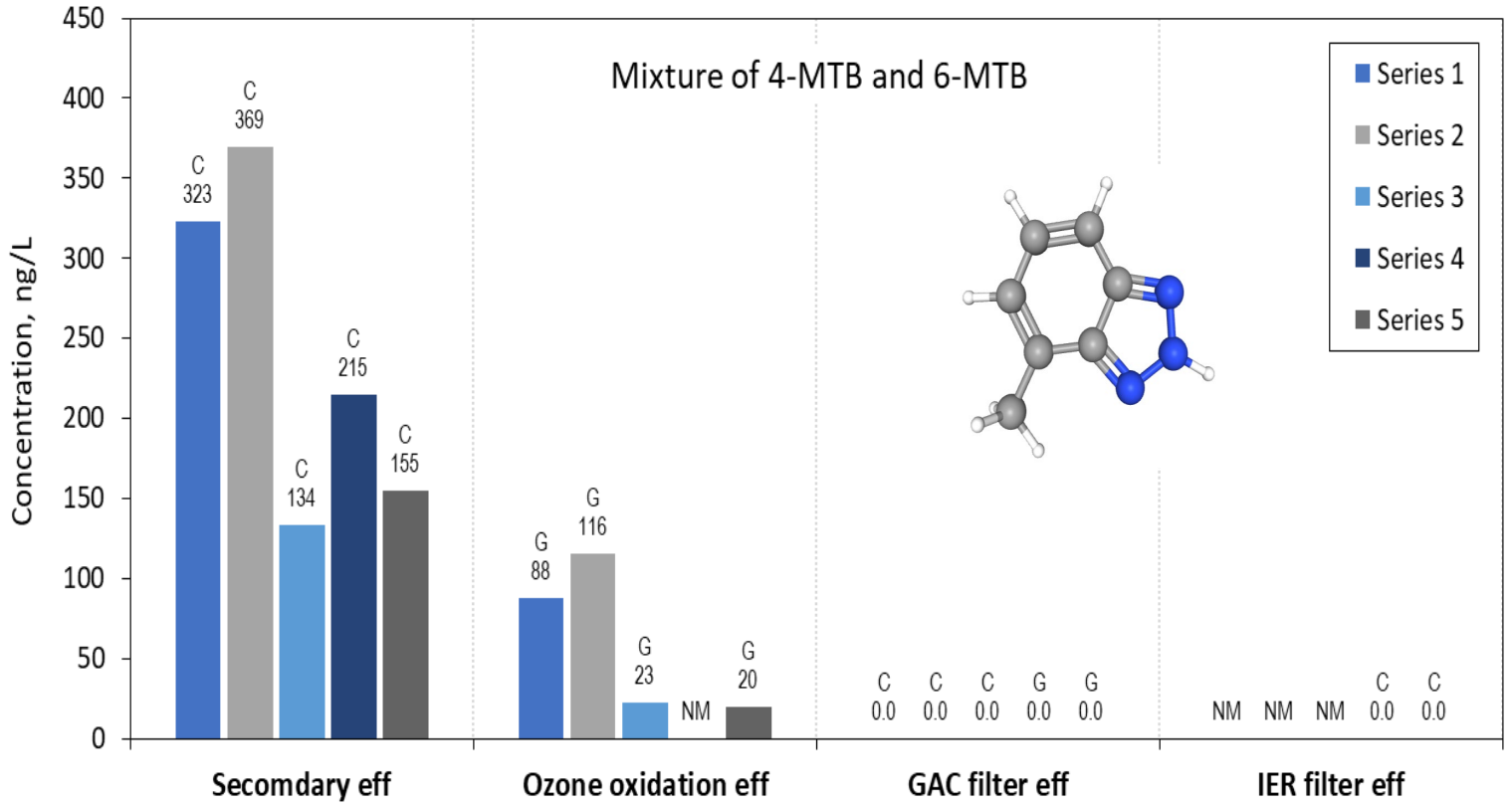


Removal of herbicides





Removal of benzotriazoles



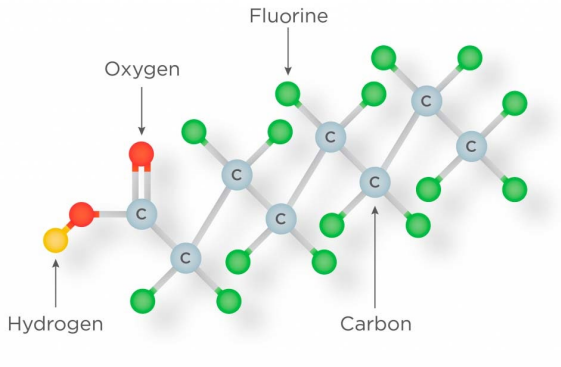
Removal of PFAS

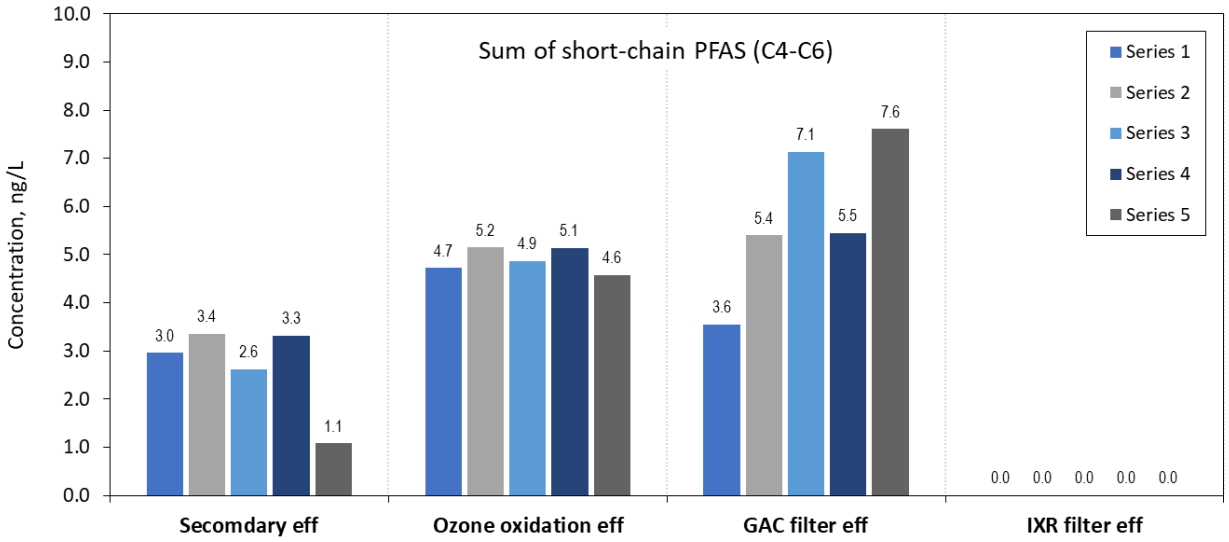
PFAS20 measured - 20 compounds:

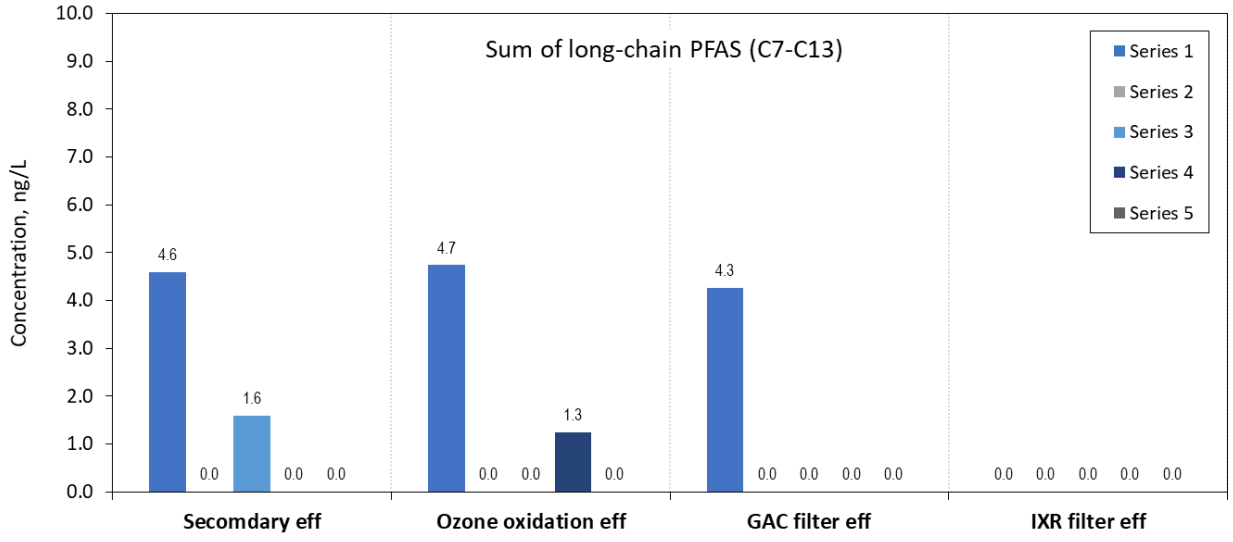
PFBA, PFPeA, PFBS, PFHxA, PFPeS, PFHpA, PFHxS, PFOA, PFHpS, PFNA, PFOS, PFNS, PFDA, PFDS, PFUnDA, FUnDS, PFDoDA, PFDoDS, PFTrDA, PFTrDS

PFASs detected - 6 compounds:

PFBA, PFBS, PFPeA, PFHxA, PFHxS, PFOA







Conclusions:



1. Good mobile pilot plant must be expensive.
2. The mobile pilot plant is a highly cost-effective tool as it can support upgrading and development of numerous wastewater treatment plants
3. The results of the pilot test confirmed high efficiency of combined ozone oxidation and GAC filtration in removing OMPs.
4. OMPs for which a minimum removal efficiency of 80% is specified in the UWWTD were removed at rates ranging from 89% to 100%.
5. Ozone dose of 10 mg O_3/L, 30 min ozone contact time and 20 min EBCT of GAC filter were identified as the optimal conditions for OMPs removal and can be used as design parameters for developing a concept of a quaternary treatment stage.
6. When ozone oxidation is used to remove micropollutants PFASs may undergo partial degradation. Analysing a limited number of PFASs to assess their removal might be insufficient.



Thank you for your attention!

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mswinarski@giwk.pl

#EMPEREST

The project EMPEREST co-financed by the Interreg Baltic Sea Region helps to drive the transition to a green and resilient Baltic Sea region.

Interreg Baltic Sea Region

Co-funded by the European Union

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